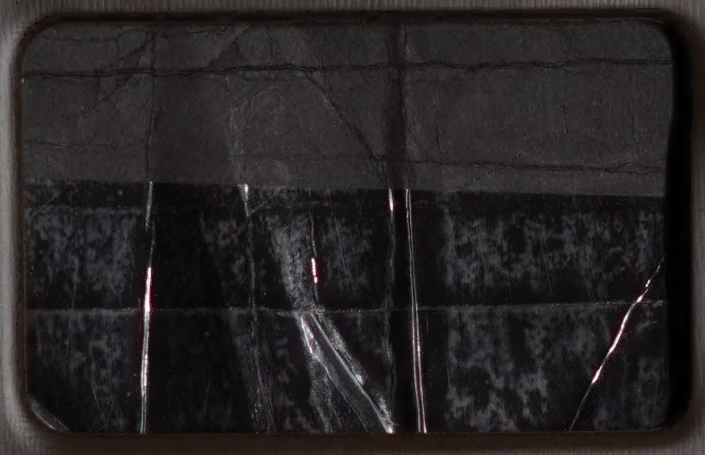


Schlumberger

# TECHNICAL DATA

# DIGITAL VOLTMETERS

A200 A203 A205
A220 A223 A225
A227

FAN OUT UNIT A204

# DIGITAL VOLTMETERS

## A200 A203 A205 A220 A223 A225 A227

Part No. A2000221

Date of Issue : July 1975

Schlumberger

THE SOLARTRON ELECTRONIC GROUP LIMITED
FARNBOROUGH HAMPSHIRE ENGLAND GU14 7PW
TEL: FARNBOROUGH 44433 (STD 0252)
CABLES: SOLARTRON FARNBOROUGH HANTS
TELEX: 858245 SOLARTRON FARNBOROUGH

# TECHNICAL MANUAL

19©73

Digitized by the Internet Archive
in 2025

https://archive.org/details/manualsplus_11192

# INTRODUCTION

*Your new digital voltmeter (dvm) is the latest in a series of sophisticated and advanced instruments. Solartron design experience has made available an accurate and sensitive range of voltmeters which, when fitted with a fan out unit, are fully programmable by remote commands.*

*The functional control layout and clear, unambiguous display make this a simple to use dvm whilst the AC and Ohms options make the basic instrument even more versatile.*

*This manual contains all the necessary information on how to operate your dvm; read it carefully so that you can use the dvm to its full capability.*

## The Display

*Some instruments use a type of display different from those illustrated in this manual. An example of an instrument with the alternative display is shown overleaf.*

*All information given in this manual applies to instruments with either display.*

*A Type A223 using a 7 Bar Neon type of display.*

As well as the shape of the numerals, the appearance and positioning of the annunciators have also changed.

The following are in column to the extreme left of the display.

| | |
|---|---|
| WAIT | Indicates an invalid display. A measurement is true when this indicator is extinguished. |
| O/L | Overload, in conjunction with a display of 19999. |
| ~ | AC value displayed. |
| REMOTE | The instrument is under remote control. |

The polarity signs, + and −, lie between the annunciator column and the numerals. The units annunciators are to the right of the numerals.

# CONTENTS


INTRODUCTION

SECTION 1 CONTROLS

A200
A203/A205
A220/A227
A223/A225
REAR PANEL

SECTION 2 TECHNICAL SPECIFICATION

SECTION 3 OPERATING INSTRUCTIONS

DC VOLTAGE MEASUREMENT
AC VOLTAGE MEASUREMENT
RESISTANCE MEASUREMENT
CURRENT MEASUREMENT

SECTION 4 MEASUREMENT TECHNIQUES

SECTION 5 DATA SYSTEMS USE

SECTION 6 PRINCIPLE OF OPERATION

SECTION 7 CIRCUIT DESCRIPTION & SERVICING INFORMATION

SECTION 8 TEST SPECIFICATION
CALIBRATION PROCEDURE
TESTING A204 FAN OUT

APPENDIX, TEST GEAR

SECTION 9 COMPONENT PARTS LIST

# SECTION 1 Controls

# A200

### Indicator

Displays units (mV or V), WAIT and REMOTE

WAIT is displayed to indicate that the display has not been updated with the result of the latest measurement.

1) When a MANUAL sample has been initiated whilst the voltmeter is in the SLOW RESPONSE mode.

2) When the voltmeter is AUTO ranging with SLOW RESPONSE.

WAIT is extinguished when the display is updated.

REMOTE is displayed when the voltmeter is under remote control.

### POWER

A push for ON - push for OFF switch for applying mains power to the voltmeter.

### RANGE

Seven mutually exclusive push-button switches for selecting

1) **AUTO:** For automatic selection of the optimum range.

2) **10mV, 100mV, 1V, 10V, 100V or 1000V DC ranges.**

If two or more buttons are pressed the least sensitive range is selected. If no buttons are pressed the 1000V range is selected.

### RESPONSE

Two mutually exclusive push-button switches for selecting

**FAST:** For unfiltered DC measurements.

**SLOW:** For filtered DC measurements. An active low pass filter provides an additional 30dB series mode rejection at 50Hz increasing at 6dB/octave (20dB/decade).

### Polarity and Overload Display

Indicated polarity is that of the red lead with respect to the black

Overload symbol flashes and the display shows 19999 for inputs which exceed 19999.

### Display

Numericals displayed by cold cathode tubes with integral decimal points. Decimal point positioning is automatic.

### CONTROL

Two mutually exclusive push-button switches for selecting

**LOCAL:** For control of the voltmeter from the front panel controls. When a Fan Out Unit is fitted and REMOTE is electrically commanded, LOCAL is overridden, REMOTE is displayed and the only effective front panel control is POWER.

**REMOTE:** For control of the voltmeter by remote electric commands via the Fan Out Unit. When REMOTE is selected REMOTE is displayed.

If no Fan Out Unit is fitted the instrument remains in the LOCAL CONTROL mode.

### RATE

Two mutually exclusive push-button switches for selecting

**10/SEC:** For automatic updating of the display every 100ms.

**MANUAL:** Initial depression of this button releases the 10/SEC button and initiates the display of a measurement. Each subsequent depression commands the display of a new measurement.

If SLOW RESPONSE is selected the display is updated 1 second after pressing the button. (During this time WAIT is displayed).

Both of these controls are effective even if REMOTE has been selected on the front panel CONTROL buttons, provided REMOTE has not been externally commanded via a Fan Out Unit.

### μV OFFSET

A potentiometer for 'backing-off' external offsets (e.g. thermal emf's from relay contacts) when making measurements on the 10mV range. Provides not less than ± 10μV offset capability.

### INPUT

'Snap-in' connector to which the signal is applied via a screened cable.

To remove the connector, pull the skirt of the connector and not the cable.

# A203
(ac mean sensing)

# A205
(rms sensing)

### Indicator

Displays units (mV, V and kΩ), WAIT and REMOTE

WAIT is displayed to indicate that the display has not been updated with the result of the latest

1) When a MANUAL sample has been initiated whilst the voltmeter is in the SLOW RESPONSE mode

2) When a MANUAL sample has been initiated whilst the voltmeter is in the AC mode

3) When the voltmeter is AUTO ranging with SLOW RESPONSE DC or Ω (ohms) measurements or with AC measurements.

WAIT is extinguished when the display is updated

REMOTE is displayed when the voltmeter is under remote control.

### POWER

A push for ON - push for OFF switch for applying mains power to the voltmeter.

### MODE

Three mutually exclusive push-button switches for selecting either DC, AC or Ω (ohms) measurements. As a safety precaution, if two, all or none of the buttons are pressed DC MODE is selected. Also, if all the buttons are released DC MODE is selected.

### RANGE

Seven mutually exclusive push-button switches for selecting

1) **AUTO:** For automatic selection of the optimum range.

2) **10mV, 100mV, 1V, 10V, 100V or 1000V DC ranges.**

3) **100mV, 1V, 10V, 100V or 1000V AC ranges.**
The 10mV DC button selects the 100mV range during AC measurement.

4) **1kΩ, 10kΩ, 100kΩ, 1MΩ or 10MΩ resistance ranges.** The 10mV DC button selects the 1kΩ range during Ω (ohms) measurement.

If two or more buttons are pressed the least sensitive range is selected. If no buttons are pressed the 1000V or 10MΩ range is selected.

### RESPONSE

**Two mutually exclusive push-button switches for selecting**

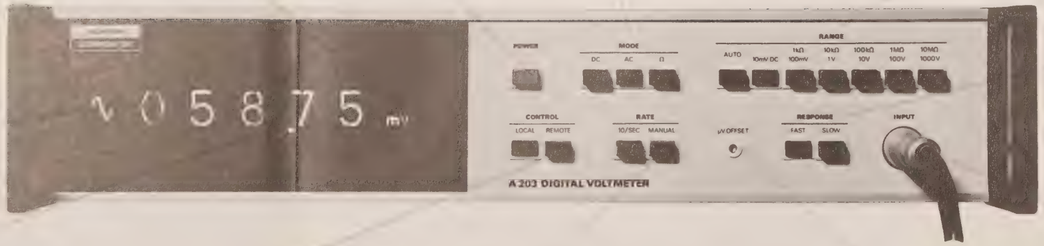
**FAST:** 1) For unfiltered DC measurements.
2) For unfiltered resistance measurements.
3) For measurement of AC signals with frequency components ⩾ 100Hz. If 10/SEC RATE is selected wait 1 second after application of the signal before reading the display.

**SLOW:** 1) For filtered DC measurements. An active low pass filter provides an additional 30dB series mode rejection at 50Hz increasing at 6dB/octave (20dB/decade).
2) For filtered resistance measurements using the same filter as for dc. Not recommended when AUTO ranging for resistances above 50kΩ.
3) For extended AC low frequency performance (down to 20Hz). If 10/SEC RATE is selected wait 5 seconds after application of the signal before reading the display. If MANUAL is selected wait 4 seconds after application of the signal before pressing the button.

When AC and AUTO range is selected SLOW RESPONSE is inhibited and the voltmeter reverts to FAST RESPONSE.

### Polarity and Overload Display

- Indicated polarity is that of the red lead with respect to the black.
- Sine wave symbol displayed in the AC mode.
- Overload symbol flashes and the display shows 19999 for inputs which exceed 19999.




### Display

Numericals displayed by cold cathode tubes with integral decimal points. Decimal point positioning is automatic.

### CONTROL

Two mutually exclusive push-button switches for selecting

**LOCAL:** For control of the voltmeter from the front panel controls. When a Fan Out Unit is fitted and REMOTE is electrically commanded, LOCAL is overridden, REMOTE is displayed and the only effective front panel control is POWER.

**REMOTE:** For control of the voltmeter by remote electric commands via the Fan Out Unit. When REMOTE is selected REMOTE is displayed.

If no Fan Out Unit is fitted the instrument remains in the LOCAL CONTROL mode.

### RATE

Two mutually exclusive push-button switches for selecting

**10/SEC:** For automatic updating of the display every 100ms.

**MANUAL:** Initial depression of this button releases the 10/SEC button and initiates the display of a measurement. Each subsequent depression commands the display of a new measurement.

If AC and/or SLOW RESPONSE is selected the display is updated 1 second after pressing the button. (During this time WAIT is displayed).

Both of these controls are effective even if REMOTE has been selected on the front panel CONTROL buttons, provided REMOTE has not been externally commanded via a Fan Out Unit.

### μV OFFSET

A potentiometer for 'backing-off' external offsets (e.g. thermal emf's from relay contacts) when making measurements on the 10mV range. Provides not less than ± 10μV offset capability.

### INPUT

'Snap-in' connector to which the signal is applied via a screened cable.

To remove the connector, pull the skirt of the connector and not the cable.

# A220

# A227

### Indicator

Displays units (mV or V), WAIT and REMOTE.

WAIT is displayed to indicate that the display has not been updated with the result of the latest measurement when a MANUAL sample has been initiated whilst the voltmeter is in the SLOW RESPONSE mode.

WAIT is extinguished when the display is updated.

REMOTE is displayed when the voltmeter is under remote control.

### POWER

A push for ON - push for OFF switch for applying mains power to the voltmeter.

**A227 only; AUTO RANGE button here**

### RANGE

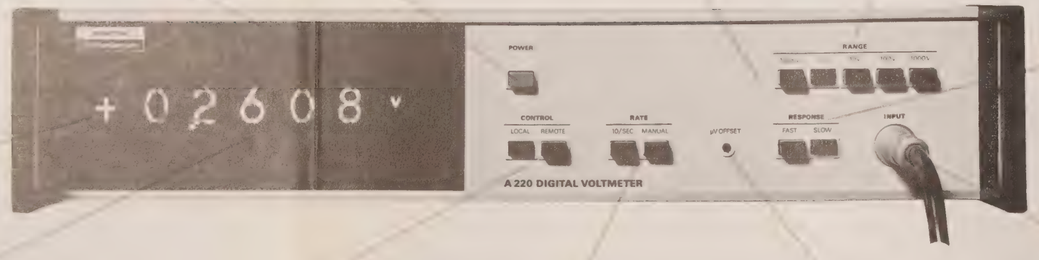
**A220**
Five mutually exclusive push button switches for selecting the **100mV,1V,10V,100V or 1000V DC ranges.**

**A227**
Six mutually exclusive push button switches for selecting:

**1) AUTO:** For automatic selection of optimum range.

**2) 100mV,1V,10V,100V or 1000V DC ranges.**

On both the A220 and A227, if two or more buttons are pressed the least sensitive range is selected.
If no buttons are pressed the 1000V range is selected.




### RESPONSE

Two mutually exclusive push-button switches for selecting

**FAST:** For unfiltered DC measurements.

**SLOW:** For filtered DC measurements. An active low pass filter provides an additional 30dB series mode rejection at 50Hz increasing at 6dB/octave (20dB/decade).

### Polarity and Overload Display

± Indicated polarity is that of the red lead with respect to the black.

= Overload symbol flashes and the display shows 19999 for inputs which exceed 19999.

### Display

Numericals displayed by cold cathode tubes with integral decimal points. Decimal point positioning is automatic.

### CONTROL

Two mutually exclusive push-button switches for selecting

**LOCAL:** For control of the voltmeter from the front panel controls. When a Fan Out Unit is fitted and REMOTE is electrically commanded, LOCAL is overridden, REMOTE is displayed and the only effective front panel control is POWER.

**REMOTE:** For control of the voltmeter by remote electric commands via the Fan Out Unit. When REMOTE is selected REMOTE is displayed.

If no Fan Out Unit is fitted the instrument remains in the LOCAL CONTROL mode.

### RATE

Two mutually exclusive push-button switches for selecting

**10/SEC:** For automatic updating of the display every 100ms.

**MANUAL:** Initial depression of this button releases the 10/SEC button and initiates the display of a measurement. Each subsequent depression commands the display of a new measurement.

If SLOW RESPONSE is selected the display is updated 1 second after pressing the button. (During this time WAIT is displayed).

Both of these controls are effective even if REMOTE has been selected on the front panel CONTROL buttons, provided REMOTE has not been externally commanded via a Fan Out Unit.

### μV OFFSET

A potentiometer for 'backing-off' external offsets (e.g. thermal emf's from relay contacts) when making measurements on the 100mV range. Provides not less than ± 100μV offset capability.

### INPUT

'Snap-in' connector to which the signal is applied via a screened cable.

To remove the connector, pull the skirt of the connector and not the cable.

# A223
(ac mean sensing)

# A225
(rms sensing)

## Indicator

Displays units (mV, V and kΩ), WAIT and REMOTE

WAIT is displayed to indicate [illegible] when updated [illegible]

1) When a MANUAL sam[illegible] whilst the voltmeter is in the SLOW RESPONSE mode.

2) When a MANUAL sa[illegible] whilst the voltmeter is in the AC mode.

WAIT is extinguished when the display is updated.

REMOTE is displayed when the voltmeter is under remote control.

## POWER

A push for ON - push for OFF switch for applying [illegible] to the voltmeter.

## MODE

Three mutually exclusive push-button switches for selecting either DC, AC or Ω (ohms) measurements. As a safety precaution, if two, all or none of the buttons are pressed DC MODE is selected. Also, if all the buttons are released DC MODE is selected.

## RANGE

Five mutually exclusive push-button switches for selecting

1) **100mV, 1V, 10V, 100V or 1000V DC ranges.**

2) **100mV, 1V, 10V, 100V or 1000V AC ranges.**

3) **1kΩ, 10kΩ, 100kΩ, 1MΩ or 100MΩ resistance ranges.**

If two or more buttons are pressed

If two or more buttons are pressed the least sensitive range is selected. If no buttons are pressed the 1000V or 10MΩ range is selected.

## RESPONSE

Two mutually exclusive push-button switches for selecting

**FAST:** 1) For unfiltered DC measurements.

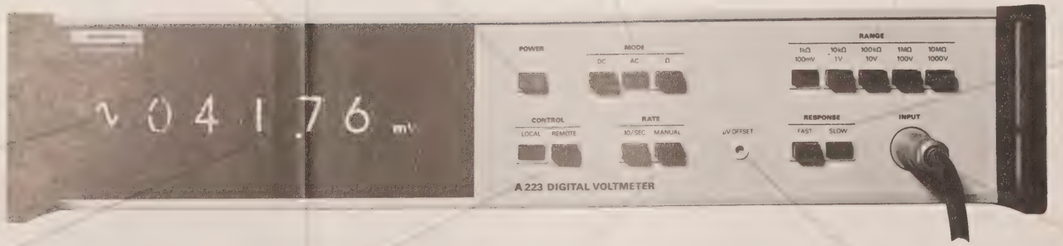
2) For unfiltered resistance measurements.

3) For measurement of AC signals with frequency components ⩾ 100Hz. If 10/SEC RATE is selected wait 1 second after application of the signal before reading the display.

**SLOW:** 1) For filtered DC measurements. An active low pass filter provides an additional 30dB series mode rejection at 50Hz increasing at 6dB/octave (20dB/decade).

2) For filtered resistance measurements using the same filter as for dc. Not recommended when AUTO ranging for resistances above 50kΩ.

3) For extended AC low frequency performance (down to 20Hz). If 10/SEC RATE is selected wait 5 seconds after application of the signal before reading the display. If MANUAL is selected wait 4 seconds after application of the signal before pressing the button.




## Polarity and Overload Display

Indicated polarity is that of the red lead with respect to the black

Sine wave symbol displayed in the AC mode.

Overload symbol flashes and the display shows 19999 for inputs which exceed 19999.

## Display

Numericals displayed by cold cathode tubes with integral decimal points. Decimal point positioning is automatic.

## CONTROL

Two mutually exclusive push-button switches for selecting

**LOCAL:** For control of the voltmeter from the front panel controls. When a Fan Out Unit is fitted and REMOTE is electrically commanded, LOCAL is overridden, REMOTE is displayed and the only effective front panel control is POWER.

**REMOTE:** For control of the voltmeter by remote electric commands via the Fan Out Unit. When REMOTE is selected REMOTE is displayed.

If no Fan Out Unit is fitted the instrument remains in the LOCAL CONTROL mode.

## RATE

Two mutually exclusive push-button switches for selecting

**10/SEC:** For automatic updating of the display every 100ms.

**MANUAL:** Initial depression of this button releases the 10/SEC button and initiates the display of a measurement. Each subsequent depression commands the display of a new measurement.

If AC and/or SLOW RESPONSE is selected the display is updated 1 second after pressing the button. (During this time WAIT is displayed).

Both of these controls are effective even if REMOTE has been selected on the front panel CONTROL buttons, provided REMOTE has not been externally commanded via a Fan Out Unit.

## μV OFFSET

A potentiometer for 'backing-off' external offsets (e.g. thermal emf's from relay contacts) when making measurements on the 100mV range. Provides not less than ± 100μV offset capability.

## INPUT

'Snap-in' connector to which the signal is applied via a screened cable.

To remove the connector, pull the skirt of the connector and not the cable.

# Rear Panel
## [all units]

**Rear Input**

Position where rear input socket can be fitted

**Fuse Holder**

98 to 128V : 750mA* SLO-BLO fuse

195 to 255V : 300mA* SLO-BLO fuse

* As indicated on MAINS SELECTOR PLATES

**Mains Selector Switches**

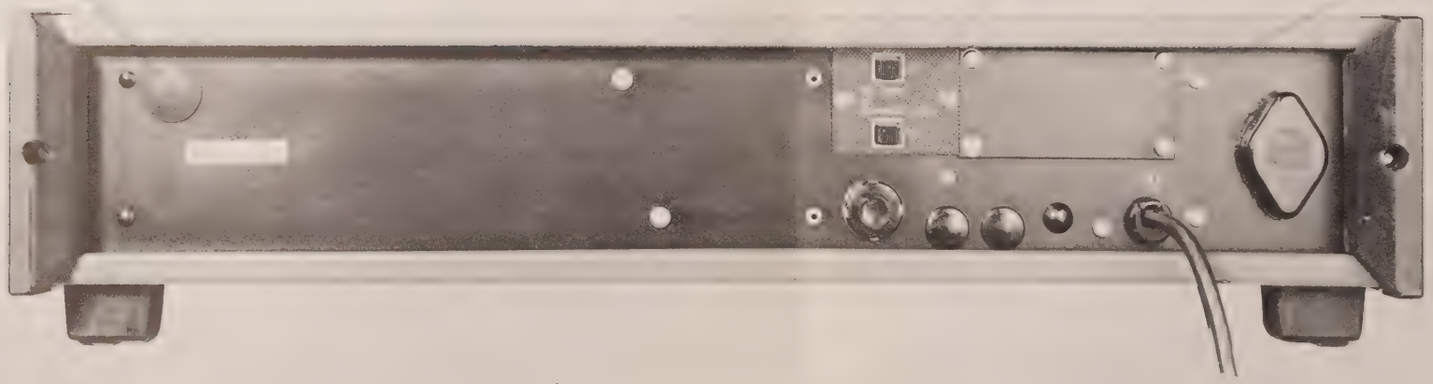
Mains voltage selection is effected by positioning the switches so that the appropriate mains selector plate can be screwed on.

There are four possible ranges of mains input:-

| | | |
|---|---|---|
| 1) 98 - 115V<br>2) 220 - 255V | 50 - 60Hz | Plate 1 |
| 3) 110 - 128V<br>4) 195 - 230V | 50 - 60Hz | Plate 2 |

**Blanking Plate**

Removed for fan out unit installation.



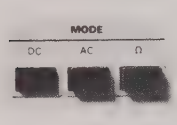
## CONTROLS

The push button controls of this series of voltmeters are arranged in six groups in accordance with the six decisions which have to be made for any measurement.

### 1. POWER

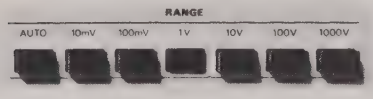
This heavy duty mains switch operates with a push on - push off action. The numerical display is always illuminated whenever the instrument is switched on and no separate warning is required. This is the only button which cannot be remotely controlled, but the voltmeter can, of course, be remotely switched ON and OFF by interruption of the mains supply.

### 2. MODE




The second group of controls select either DC, AC or Ohms. These buttons are mutually exclusive and pressing any one automatically releases the one previously selected. In the event of a user forcing in more than one of these buttons at the same time (misuse) the voltmeter automatically reverts to the DC mode as a safety precaution. DC only instruments (A200, A220, A227) have no mode switches.

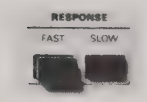
### 3. RANGE




This row of buttons selects the sensitivity setting. Again, pressing one button releases any previously selected in the group. There is one button for each range and on the A200, A203, A205 and A227 there is also an auto range control. Pressing the AUTO button causes the voltmeter to automatically select the correct range for any input voltage from 1$\mu$V to 1000V. Unless there is a particular reason for pre-selecting a fixed range, the use of auto range is recommended - there is no reduction of accuracy, noise rejection or input resistance and in the event of accidental overload, the voltmeter automatically moves to the appropriate range. If more than one range button is pushed, the least sensitive will be selected.

A word of caution: there are more dc ranges than ac or ohms ranges and the 10mV button, although applicable only to dc, could be pressed when AC or $\Omega$ has been selected. The voltmeter does not respond to this invalid command and selects instead, the 100mV or 1k$\Omega$ range. The units display and decimal point setting will always be correct. As it is normal to think in decimal terms, the legend which identifies each range follows a 1, 10, 100 sequence. However, there is a 99% overrange capability on all ranges. For example, the full scale value of the 1V range is, in fact, 1.9999V. There is no degradation of the performance specification in this upper part of the scale. On voltage measurement however, the maximum recommended input is 1200V dc or 1.2kV peak (850V rms).

## 4. RESPONSE




As far as dc and ohms measurements are concerned, these controls should be regarded as a luxury and not required in all but the most exceptional circumstances. In general they should be left in the FAST mode. For dc and resistance the SLOW button selects an active low pass filter to reduce the effects of any noise interference. However, because the voltmeter is an integrating type (with mains locked integration on A200, A203 and A205), it inherently rejects mains frequency interference and its harmonics without the filter. SLOW is therefore seldom required. In doubtful cases the effect of the control should be observed: if any change in the reading results from the use of the filter this must be as a result of noise being rejected and SLOW should be chosen in this instance.

The use of a filter introduces long time constants into an otherwise fast acting instrument, and the user should therefore exploit the inherent noise rejecting properties of this instrument and avoid unnecessary use of the filter.

For ac measurement this control has a different purpose. Inherent in the design of an ac measurement system is the compromise between response time and low frequency performance. Therefore, to cater for a wide variety of applications this choice is left to the user. With AC FAST, the response time to 0.1% is 1 second.

If the input signal contains frequency components below 100Hz the reading will fluctuate under the influence of the low frequency. With AC SLOW, the response time is increased to 5 seconds, but accurate readings can be taken on signals which include frequency components down to 20Hz. The upper frequency limit of measurement is unaffected by FAST/SLOW selection.

## 5. RATE

A feature of these voltmeters is that they operate on a continuous basis, always responding to the applied signal. Whenever they are switched on they are making 10 measurements each second, although the result of every measurement will be displayed only when the 10/SEC button is pressed. When MANUAL is selected the voltmeter still makes 10 measurements each second, but the display is updated only upon pressing the button.

As an added precaution, the auto range circuitry continues to protect the instrument when MANUAL and AUTO have been selected. Even though the display retains the value applicable when the last sample was called for, in this mode of operation the instrument may in fact have moved to a different range under the influence of a change in the input signal. However, the information on the display still remains applicable to the last command measurement.

## 6. CONTROL

As indicated by the legend these controls affect the changeover from manual (front panel) to remote control. When LOCAL is selected the REMOTE button is released and any remote electrical commands (except a call for REMOTE) are ignored.

The LOCAL/REMOTE buttons are fitted regardless of whether or not Fan-Out Unit A204 has been installed. If there is no fan-out unit and the REMOTE button is operated, local control is retained. With a fan-out unit, when REMOTE is selected control of MODE (DC, AC and Ω), RANGE (including AUTO range) and RESPONSE (FAST/SLOW) is possible only by external electrical commands via the fan-out unit. Other than POWER the only buttons still operative are those for RATE so that front panel control is still available to command either 10/SEC or single sample. In addition, with 10/SEC released, a measurement may be remotely initiated by electrical pulse or contact closure.

A feature made available by the CONTROL switches is that users can remotely command both repetitive or single sample. This is achieved in the following way:-

Select REMOTE and 10/SEC by means of the front panel switches.

For "single shot" sample call REMOTE electrically via the fan-out and initiate each sample by either contact closure or pulse application via the fan-out unit.

For 10/SEC sampling do not electrically command REMOTE.

In both cases control of the remaining functions is by remote command via the fan-out unit.

**Front Panel Lock-Out**

Not apparent from the front panel is an extra facility known as Front Panel Lock-Out. Under the control of an external electrical command (command REMOTE) applied via Fan-Out Unit A204, the action of all front panel controls can be inhibited with the exception of POWER. In this condition all control must be by electrical command and the LOCAL button cannot be used to regain manual control. The user is reminded of this condition by the word REMOTE being displayed.

This feature prevents unauthorised use when the voltmeter is committed within a system or, with suitable programming of the REMOTE command, enables a test sequence to include both automatic and operator control.

**INPUT CONNECTOR**

The input connector simply pushes into the front panel socket with a "snap-in" action. This cannot be released by pulling on the cable, but separation occurs only when the skirt of the connector is pulled away from the panel.

The "snap-in" connector has been chosen to permit the use of a long input lead which may be required when the voltmeter is rack mounted. Experience with push-on 4mm connectors has shown that they tend to fall off under the weight of a long lead.

The skirt of the chosen connector acts as an isothermal chamber preventing temperature differentials which would give rise to errors caused by thermal emf's. The standard input lead provides connection for signal high (red) and signal low (black). It will be seen that the connector contains five pins and users wishing to use a three terminal driven guard, input configuration should use input lead EX 3183 available as an optional extra. (A guide to three terminal measurement in "noisy" conditions can be obtained from the Solartron publication "Digital Voltmeters and Interference" which is free on request). This same lead is also used for a 4 terminal ohms measurement which is described later in this manual. The input to the voltmeter is completely isolated from earth and from all of the programming inputs and digital outputs.

**Rear Input**

This is fitted only on request and is wired in parallel with the normal front input. The input capacitance is increased by 80pF. The back panel includes a cut-out for the later addition of a rear input, and users installing their own rear connector are reminded that the use of p.t.f.e. coated wire is necessary to maintain the isolation characteristics.

### μV OFFSET

A200, A203 and A205 include a sophisticated chopper input amplifier to maintain very high integrity μV measurement. The stability of the input stage is such that, provided 90 minutes initial warm up is allowed, the drift with time is less than 1μV per week on the 10mV range; initial warm up on all other range is 60 minutes.

External conductors, however, may introduce thermal errors and the μV OFFSET control can be used to offset such effects. The range of offset is ± 15μV.

### DISPLAY

The display area is covered by a tinted screen laminated with a circularly polarised membrane to inhibit stray light or reflected light from the indicator tubes. The front surface is lightly frosted to eliminate surface reflection from overhead lights or light coloured garments worn by the user. Very slight de-focusing results from this frosting.

The display information is updated either ten times per second or on manual command as described earlier.

From left to right the information is:-

a) ± **Automatic polarity indication.** The polarity is that of the red lead with respect to the black.

b) ∿ This sign is displayed when AC MODE is selected.

c) ◎ Overrange indication is given by a flashing symbol when the input exceeds 19999. The user is not required to remember the full scale of the instrument.

d) **Numerical Indication.** Cold cathode neon number tubes, which have been proved to have extremely long life, are used to present the result of measurement.

e) **Decimal Point.** This is positioned automatically in conjunction with the units display.

f) **Units.** V, mV and kΩ. Display of the units is automatic and appropriate to the sensitivity and mode. Units, decimal point and numerical information are updated only as a result of digitise command as directed by the RATE control.

g) **Wait.** When the user selects a slow mode of operation, for example SLOW and AUTO range, an appreciable period of time may elapse before the new measurement is complete. During this time the result of the previous measurement is retained by the display. As a precaution against the wrong value being noted the legend WAIT lights up and is only extinguished when the new result is displayed.

h) **Remote.** Indication that the instrument is under either remote control or front panel lock-out. Only applicable when fan-out A204 is fitted.

### Rack Mounting

The overall dimensions conform to international standards for rack mounting. The instrument can be rack mounted within its case with no additional protection required. Users who wish to remove the top, bottom and side covers can do so by undoing the two screws which secure the side covers and sliding out all the covers starting with the sides. For rack mounting the combination handle/ears should be substituted for the normal handles. These combination rack mounting handles are supplied in the accessory pack with each voltmeter.

# SECTION 2 Technical Specification

**DC RANGES**

| Range | Sensitivity | Full Scale | Input Resistance |
|---|---|---|---|
| 10mV* | 1μV | 19.999mV | > 1000MΩ |
| 100mV | 10μV | 199.99mV | > 10000MΩ |
| 1V | 100μV | 1.9999V | > 10000MΩ |
| 10V | 1mV | 19.999V | > 10000MΩ |
| 100V | 10mV | 199.99V | 10MΩ ± 0.1% |
| 1000V | 100mV | 1200.0V** | 10MΩ ± 0.1% |

* A200/A203/A205 only.

** 1000V range: Although full scale remains 1999.9V it is advisable not to exceed the given value.

**AC RANGES** (A203, A205, A223, A225)

| Range | Sensitivity | Full Scale | Input Impedance* |
|---|---|---|---|
| 100mV | 10μV | 199.99mV | 10MΩ/< 150pF |
| 1V | 100μV | 1.9999V | 10MΩ/< 150pF |
| 10V | 1mV | 19.999V | 1MΩ/< 100pF |
| 100V | 10mV | 199.99V | 1MΩ/< 100pF |
| 1000V | 100mV | 1000V** | 1MΩ/< 100pF |

*Input capacitance measured between Hi and Lo at input socket excluding input cable. Capacitance is increased by 80pF if rear input socket is fitted.

** 1000V Range: Although full scale remains 1999.9V 1.2kV peak (850V rms) must not be exceeded.

**OHMS RANGES** (A203, A205, A223, A225)

| Range | Sensitivity | Full Scale | Test Current |
|---|---|---|---|
| 1kΩ | 100mΩ | 1.9999kΩ | 600μA |
| 10kΩ | 1Ω | 19.999kΩ | 600μA |
| 100kΩ | 10Ω | 199.99kΩ | 60μA |
| 1MΩ | 100Ω | 1999.9kΩ | 0.6μ A |
| 10MΩ | 1kΩ | 19999.kΩ | 0.6μ A |

**REMOTE RANGE:** The remote selection of any range may be commanded via optional Fan-Out unit A204.

**OVERLOAD:** An overload symbol flashes and the display shows 19999 for inputs which exceed 19999.

**AUTO RANGE:** Auto is available on A200, A203, A205 and A227 only. Operates on all ranges.

**AC SCALING:**

(A203, A223) The instrument senses the mean value of the ac component and displays the rms value - assuming a sine wave signal.

(A205, A225) The instrument senses the true rms value of the ac component regardless of waveshape.

## SHORT TERM ACCURACY

For 24 hours and within ± 1°C of temperature stability. Resolution and linearity errors are included.

**DC RANGES**

| Range | A200/A203/A205 | | A220/A223/A225/A227 | |
|---|---|---|---|---|
| | of reading | of full scale | of reading | of full scale |
| 10mV | ± 0.01% | ± 0.005% | | |
| 100mV, 1V, 10V, 100V and 1000V | ± 0.005% | ± 0.005% | ± 0.01% | ± 0.005% |

## LONG TERM ACCURACY

AC Voltage, A205 and A225 90 days ± 5°C. All other ranges, modes and models 1 year ± 5°C.

Assumes occasional front panel zero adjustment. Unless otherwise stated, full scale = 20000.

**DC RANGES**

| Range | A200/A203/A205 | | A220/A223/A225/A227 | |
|---|---|---|---|---|
| | of reading | of full scale | of reading | of full scale |
| 10mV | ± 0.02% | ± 0.005% | – | – |
| 100mV | ± 0.02% | ± 0.005% | ± 0.02% | ± 0.01% |
| 1V | ± 0.02% | ± 0.005% | ± 0.02% | ± 0.005% |
| 10V | ± 0.02% | ± 0.005% | ± 0.02% | ± 0.005% |
| 100V | ± 0.025% | ± 0.005% | ± 0.05% | ± 0.005% |
| 1000V | ± 0.025% | ± 0.005% | ± 0.05% | ± 0.005% |

**AC RANGES** 40Hz to 20kHz (mean sensing)

| Range | A203 | | A223 | |
|---|---|---|---|---|
| | of reading | of full scale | of reading | of full scale |
| 100mV | ± 0.05% | ± 0.03% | ± 0.05% | ± 0.03% |
| 1V | ± 0.05% | ± 0.03% | ± 0.05% | ± 0.03% |
| 10V | ± 0.1% | ± 0.03% | ± 0.1% | ± 0.03% |
| 100V | ± 0.1% | ± 0.03% | ± 0.1% | ± 0.03% |
| 1000V | ± 0.1% | ± 0.06% | ± 0.1% | ± 0.06% |

**AC RANGES** 20Hz to 100kHz (mean sensing)

| Range | A203 | | A223 | |
|---|---|---|---|---|
| | of reading | of full scale | of reading | of full scale |
| 100mV | 1% | ± 0.03% | 1% | ± 0.03% |
| 1V | 1% | ± 0.03% | 1% | ± 0.03% |
| 10V | 1% | ± 0.03% | 1% | ± 0.03% |
| 100V | 1% | ± 0.03% | 1% | ± 0.03% |
| 1000V | 1% | ± 0.06% | 1% | ± 0.06% |

**AC RANGES** 40Hz to 10kHz (A205/A225) (sine wave inputs between 1% and 100% of full scale)

| Range | of reading | of full scale |
|---|---|---|
| 100mV | ± 0.1% | ± 0.1% |
| 1V | ± 0.1% | ± 0.1% |
| 10V | ± 0.1% | ± 0.1% |
| 100V | ± 0.1% | ± 0.1% |
| 1000V | ± 0.1% | ± 0.1% |

**AC RANGES** 10Hz to 100kHz (A205/A225) (sine wave inputs between 1% and 100% of full scale)

| Range | of reading | of full scale |
|---|---|---|
| 100mV | ± 0.2% | ± 1.0% |
| 1V | ± 0.2% | ± 1.0% |
| 10V | ± 0.2% | ± 1.0% |
| 100V | ± 0.2% | ± 1.0% |
| 1000V | ± 0.2% | ± 1.0% |

**RESISTANCE RANGES**

| Range | A203/A205 | | A223/A225 | |
|---|---|---|---|---|
| | of reading | of full scale | of reading | of full scale |
| 1kΩ | ± | ± 0.01% | ± 0.01% | ± 0.01 |
| 10kΩ | ± | ± 0.01% | ± 0.01% | ± 0.01% |
| 100kΩ | ± | ± 0.01% | ± 0.01% | ± 0.01% |
| 1MΩ | ± | ± 0.01% | ± 0.05% | ± 0.01% |
| 10MΩ | ± | ± 0.02% | ± 0.5% | ± 0.02 |

## TEMPERATURE EFFECTS

**DC RANGES**

| | A200/A203/A205 | A220/A223/A225/A227 |
|---|---|---|
| **Zero Drift 0 - 50°C :** | ± 0.2μV per °C | ± 1μV per °C |

**Coefficient of Reading 0 - 50°C**

| Range | A200/A203/A205 | A220/A223/A225/A227 |
|---|---|---|
| 10mV | < ± 0.002% per °C | – |
| 100mV | < ± 0.002% per °C | < ± 0.002% per °C |
| 1V | < ± 0.002% per °C | < ± 0.002% per °C |
| 10V | < ± 0.002% per °C | < ± 0.002% per °C |
| 100V | < ± 0.0025% per °C | < ± 0.003% per °C |
| 1000V | < ± 0.0025% per °C | < ± 0.003% per °C |

**AC RANGES**

**Coefficient of Reading 0 - 50°C. 20Hz - 100kHz**

| Range | A203 | A223 |
|---|---|---|
| 100mV | < ± 0.0025% per °C | < ± 0.0025% per °C |
| 1V | < ± 0.0025% per °C | < ± 0.0025% per °C |
| 10V | < ± 0.015% per °C | < ± 0.015% per °C |
| 100V | < ± 0.015% per °C | < ± 0.015% per °C |
| 1000V | < ± 0.015% per °C | < ± 0.015% per °C |

**Coefficient of reading 0 - 50°C. 10Hz to 100kHz A205/A225**

All ranges

± 0.015% of reading

± 0.001% of full scale

RESISTANCE RANGES

Zero Drift 0 - 50°C

| Range | A203/A205 | A223/A225 |
|---|---|---|
| 1kΩ | 0.001% of full scale per °C | 0.001% of full scale per °C |
| 10kΩ | 0.0001% of full scale per °C | 0.0001% of full scale per °C |
| 100kΩ | 0.0001% of full scale per °C | 0.0001% of full scale per °C |
| 1MΩ | 0.001% of full scale per °C | 0.001% of full scale per °C |
| 10MΩ | 0.001% of full scale per °C | 0.001% of full scale per °C |

Coefficient of Reading 0 - 50°C

| Range | A203/A205 | A223/A225 |
|---|---|---|
| 1kΩ | < ± 0.002% per °C | < ± 0.004% per °C |
| 10kΩ | < ± 0.002% per °C | < ± 0.004% per °C |
| 100kΩ | < ± 0.002% per °C | < ± 0.004% per °C |
| 1MΩ | < ± 0.002% per °C | < ± 0.004% per °C |
| 10MΩ | < ± 0.002% per °C | < ± 0.004% per °C |

## CREST FACTOR A205/A225 only

4:1 at full scale up to 20kHz

## INPUT CHARACTERISTICS

Input voltage should not exceed 100V whilst changing mode.

**DC RANGES**

**Input Current:** $< 10^{-10}$ A

**Overload**

**10mV, 100mV, 1V, 10V Ranges**

Max. permitted input: 200V continuous (1200V for up to 200ms)

**100V, 1000V Ranges**

Max. permitted input: 1200V

Input resistance: 10MΩ ± 0.1%

AC RANGES

Overload

100mV, 1V Ranges

Max. permitted input: 300V peak (1200V peak for up to 2s) Note. On models A205 and A225 the input voltage/frequency must not exceed 6 x $10^6$ VHz

10V, 100V, 1000V Ranges

Max. permitted input: 1.2kV peak (850V rms)

RESISTANCE RANGES

Overload

All ranges

Max. permitted input 300V. peak

**ISOLATION IMPEDANCE**

Guard to Chassis: $> 10^{10}\Omega$ and $< 500$pF

**RESPONSE TIMES**

**Auto Range Response Time**

| | |
|---|---|
| DC FAST: | Shall have selected the correct range within 0.7s. |
| DC SLOW: | Shall have selected the correct range within 6s. |
| AC FAST: | Shall have selected the correct range within 6s, A203/A223 or 7s, A205. |
| AC SLOW: | Not available. Voltmeter reverts to AC, FAST AUTO range. |
| Ω FAST: | Shall have selected the correct range within 0.7s for resistances $\leq 1M\Omega$ |
| Ω SLOW: | As DC SLOW for values $<50k\Omega$<br>Not recommended for values $>50k\Omega$ |

## INTERFERENCE REJECTION – SERIES MODE

The ratio of the peak interference at the input terminals to one digit reading error. These figures apply providing that the applied signal plus the noise does not exceed 120% of full scale, on each range (but note the maximum permissible input on the 1000V range).

**DC FAST**

A200/A203/A205: $>$ 70dB at mains frequency (Nominal 50Hz ± 2%)

A220/A223/A225/A227: $>$ 36dB at 50Hz $\pm$ 1%

**DC SLOW**

A low pass active filter increases the above figures by 30dB at 50Hz increasing at 6dB/Octave.

## INTERFERENCE REJECTION – COMMON MODE

The ratio of the peak interference, applied between signal source and instrument ground (chassis), to the reading error, when there is 1kΩ unbalance between the high and low signal paths.

The maximum common mode voltage must not exceed 500V dc or peak ac.

**DC RANGES** With Guard connected to Lo in the standard input cable (2 terminal measurement):

| | A200/A203/A205 | A220/A223/A225/A227 |
|---|---|---|
| DC | > 140dB | > 140dB |
| 50Hz FAST | > 145dB | > 110dB |
| 50Hz SLOW | > 174dB | > 155dB |

**AC RANGES** With guard connected to Lo in the standard input cable (2 terminal measurement)

| | A203/A205 | A223/A225 |
|---|---|---|
| DC | > 140dB | > 140dB |
| 50Hz FAST | > 40dB | > 40dB |
| 50Hz SLOW | > 40dB | > 40dB |

**DC RANGES** With Guard connected to the source of common mode (3 terminal measurement).

| | A200/A203/A205 | A220/A223/A225/A227 |
|---|---|---|
| DC | > 150dB | > 150dB |
| 50Hz FAST | > 160dB | > 125dB |
| 50Hz SLOW | > 174dB | > 155dB |

**AC RANGES** With Guard connected to the source of common mode (3 terminal measurement).

| | A203/A205 | A223/A225 |
|---|---|---|
| DC | > 150dB | > 150dB |
| 50Hz FAST | > 60dB | > 60dB |
| 50Hz SLOW | > 60dB | > 60dB |

## TEMPERATURE RANGE

**Operation:** This specification applies for operation in the ambient ranges 0 - 40°C (A220/A223/A225/A227) and 0 - 55°C (A200/A203/A205)

Storage: The instrument can be stored at ambients between -30°C and +70°C.

## MAINS SUPPLY

This specification relates to supplies of 117/234V + 10% -15%, 50Hz or 60Hz. Modification is necessary to achieve full interference rejection at 60Hz.

Consumption: 40VA.

AC RANGES

Overload

100mV, 1V Ranges

Max. permitted input: 300V peak (1200V peak for up to 2s) Note. On models A205 and A225 the input voltage/frequency must not exceed $6 \times 10^6$ VHz

10V, 100V, 1000V Ranges

Max. permitted input: 1.2kV peak (850V rms)

RESISTANCE RANGES

Overload

All ranges

Max. permitted input: 300V. peak

**ISOLATION IMPEDANCE**

Guard to Chassis: $> 10^{10}\Omega$ and $< 500$pF

**RESPONSE TIMES**

**Auto Range Response Time**

DC FAST: Shall have selected the correct range within 0.7s.

DC SLOW: Shall have selected the correct range within 6s.

AC FAST: Shall have selected the correct range within 6s, A203/A223 or 7s, A205.

AC SLOW: Not available. Voltmeter reverts to AC, FAST AUTO range.

Ω FAST: Shall have selected the correct range within 0.7s for resistances $\leq 1M\Omega$

Ω SLOW: As DC SLOW for values $<50k\Omega$
Not recommended for values $>50k\Omega$

## INTERFERENCE REJECTION – SERIES MODE

The ratio of the peak interference at the input terminals to one digit reading error. These figures apply providing that the applied signal plus the noise does not exceed 120% of full scale, on each range (but note the maximum permissible input on the 1000V range).

**DC FAST**

A200/A203/A205: $>$ 70dB at mains frequency (Nominal 50Hz ± 2%)

A220/A223/A225/A227: $>$ 36dB at 50Hz $\pm$ 1%

**DC SLOW**

A low pass active filter increases the above figures by 30dB at 50Hz increasing at 6dB/Octave.

## INTERFERENCE REJECTION – COMMON MODE

The ratio of the peak interference, applied between signal source and instrument ground (chassis), to the reading error, when there is 1kΩ unbalance between the high and low signal paths.

The maximum common mode voltage must not exceed 500V dc or peak ac.

**DC RANGES** With Guard connected to Lo in the standard input cable (2 terminal measurement):

| | A200/A203/A205 | A220/A223/A225/A227 |
|---|---|---|
| DC | > 140dB | > 140dB |
| 50Hz FAST | > 145dB | > 110dB |
| 50Hz SLOW | > 174dB | > 155dB |

**AC RANGES** With guard connected to Lo in the standard input cable (2 terminal measurement)

| | A203/A205 | A223/A225 |
|---|---|---|
| DC | > 140dB | > 140dB |
| 50Hz FAST | > 40dB | > 40dB |
| 50Hz SLOW | > 40dB | > 40dB |

**DC RANGES** With Guard connected to the source of common mode (3 terminal measurement).

| | A200/A203/A205 | A220/A223/A225/A227 |
|---|---|---|
| DC | > 150dB | > 150dB |
| 50Hz FAST | > 160dB | > 125dB |
| 50Hz SLOW | > 174dB | > 155dB |

**AC RANGES** With Guard connected to the source of common mode (3 terminal measurement).

| | A203/A205 | A223/A225 |
|---|---|---|
| DC | > 150dB | > 150dB |
| 50Hz FAST | > 60dB | > 60dB |
| 50Hz SLOW | > 60dB | > 60dB |

## TEMPERATURE RANGE

**Operation:** This specification applies for operation in the ambient ranges 0 - 40°C (A220/A223/A225/A227) and 0 - 55°C (A200/A203/A205)

Storage: The instrument can be stored at ambients between -30°C and +70°C.

## MAINS SUPPLY

This specification relates to supplies of 117/234V + 10% -15%, 50Hz or 60Hz. Modification is necessary to achieve full interference rejection at 60Hz.

Consumption: 40VA.

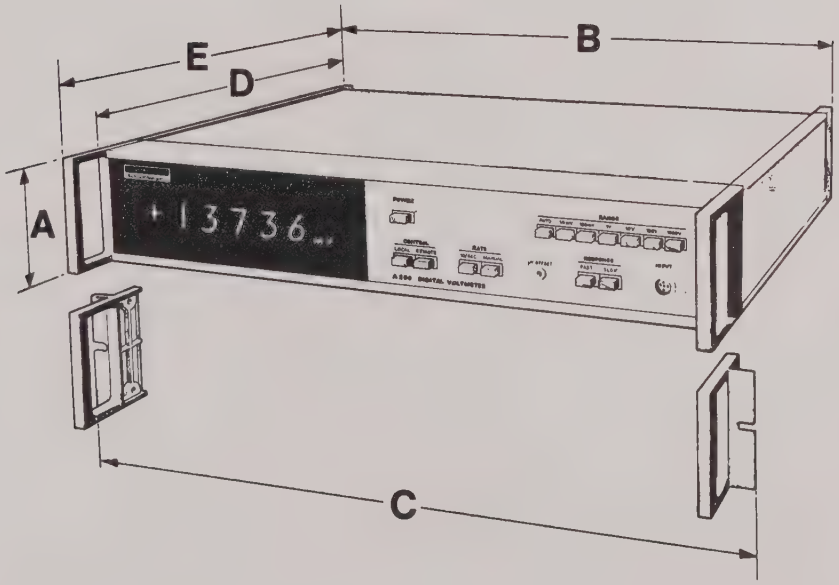
**Fan Out Unit A204**

| | |
|---|---|
| **Outputs:** | TTL Compatible.<br>High (Logic 1) + 2.4V to + 6V from a 6kΩ source<br>Low (Logic 0) – 0.5V to + 0.5V at 10mA 'sink'. |
| **Inputs:** | TTL Compatible.<br>High (Logic 1) + 2.4V to + 6V or open circuit.<br>Low (Logic 0) – 0.5V to + 0.5V at 5mA 'sink'. |

**Pulse Sample**

| | |
|---|---|
| Pulse Amplitude: | +3V to +8V |
| Duration: | > 10μs. |
| Input Impedance: | > 10kΩ |

## DIMENSIONS




| | | |
|---|---|---|
| **A** | = | 88mm (3.46in) |
| **B** | = | 442mm (17.40in) |
| **C** | = | 482mm (18.98in) |
| **D** | = | 322.58mm (12.70in) Without side covers. |
| **E** | = | 362.58mm (14.28in) Without side covers. |

**Weight**

7kg (15½lb) (Dependent upon model)

## ACCESSORIES

Each voltmeter is supplied with the following:-

| | Solartron Part No. |
|---|---|
| Signal Input Lead with 4mm Plug Terminations | A2000168 |
| Test Prod (Red) | 351901020 |
| Test Prod (Black) | 351901010 |
| Croc. Clip (Red) | 355900670 |
| Croc. Clip (Black) | 355900660 |
| Fuse 750mA SLO-BLO (2 off) | 360103070 |
| Fuse 300mA SLO-BLO (2 off) | 360103170 |
| Handle, Rack Mounting | A2000111 |

Each fan out unit is supplied with the following:-

| | |
|---|---|
| 50 Way Plug (BICC MS50 RN–BR118) (1 off) | 354002340 |
| Pins (BICC RM20M – 12 – D29) (50 off) | 354001610 |

# SECTION 3 Operating Instructions

**PRELIMINARY ADJUSTMENTS**

Check that the instrument is set to operate from the local mains supply.

Check that the correct fuse is fitted.

300mA* SLO-BLO for mains voltage between 195V and 255V

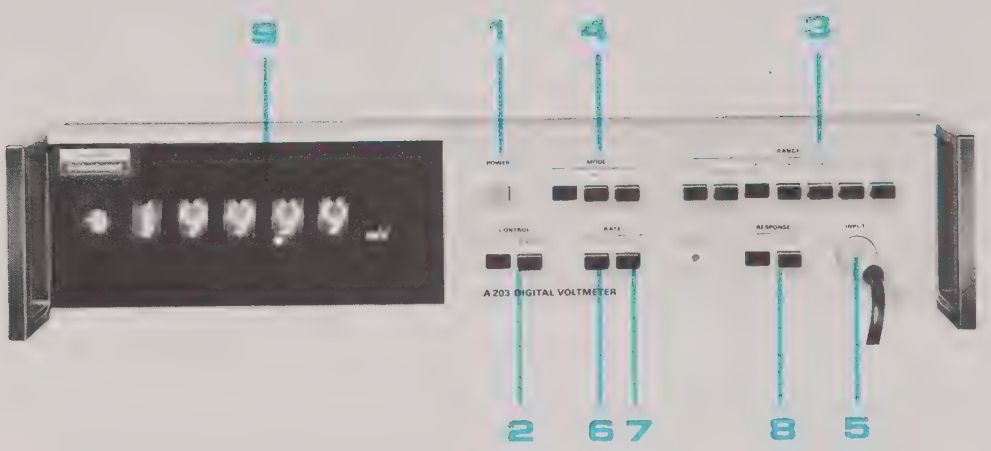
750mA* SLO-BLO for mains voltage between 98V and 128V

Connect a suitable plug to the mains lead:-

| | | |
|---|---|---|
| BROWN | - | LINE |
| BLUE | - | NEUTRAL |
| GREEN/YELLOW | - | EARTH |

* As indicated on Mains Selector Plate

## DC VOLTAGE MEASUREMENT




Although the maximum dc input voltages that may safely be applied to the instrument are:

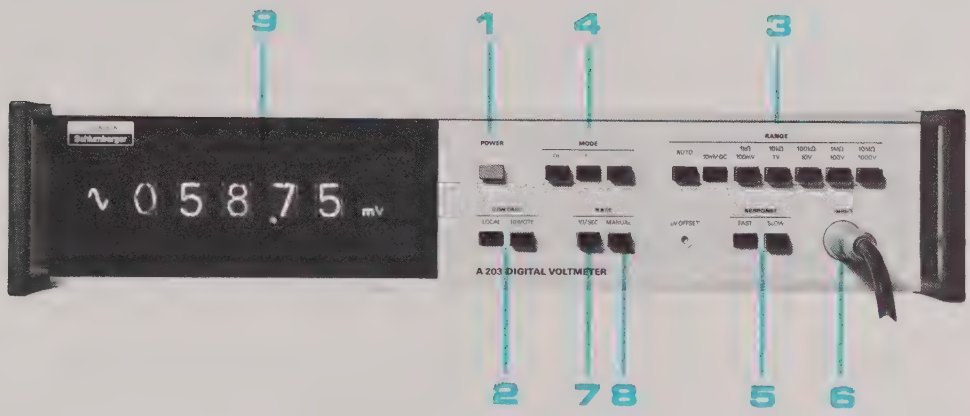
i) 1200V on the 1000V and 100V ranges

ii) 200V on the 10V, 1V, 100mV and 10mV ranges

the 10V, 1V, 100mV and 10mV ranges will withstand 1200V for up to 200ms. Thus, for AUTO range purposes, the range of input voltages can be from 0 to 1200V.

1. Switch POWER on.
2. Select LOCAL or REMOTE. If the instrument is fitted with a fan out unit and REMOTE is selected see the section of this manual which covers remote operation for a list and description of the remote control facilities. If LOCAL is selected, read on from step 3.
3. Choose an appropriate range or AUTO range.
4. If the instrument is an A203 or A223 press the DC MODE push-button.
5. Connect the input lead to the unknown voltage source, red to signal high and black to signal low.
6. Press the 10/SEC push-button for repetitive measurement or, alternatively,
7. Press the MANUAL push-button for 'single shot' measurement.
8. Select SLOW or FAST RESPONSE for filtered or unfiltered measurement. If in doubt about the necessity to use the filter, press the SLOW button and if no change in the reading occurs then the filter is unnecessary. If there is a difference between the results of the filtered and unfiltered measurement, then the result with the filter is correct.
9. Read the voltage from the display and, if necessary, downrange to obtain greater sensitivity. The indicated polarity is that of the red lead with respect to the black.

## AC VOLTAGE MEASUREMENT




Although the maximum ac voltages which may safely be applied to the instrument are:-

i) 1200V peak (846V rms) on the 100V and 10V ranges
ii) 300V peak on the 1V and 100mV ranges

} (or less than $6 \times 10^6$ VHz on A205 and A225).

the 1V and 100mV ranges will withstand 1200V peak for up to 2 seconds. Thus, for AUTO range purposes the range of input voltage can be 0 to 1200V peak.

1. Switch POWER on.

2. Select LOCAL or REMOTE. If a fan out unit is fitted and REMOTE is selected, see the section of this manual which covers remote operation for a list and description of the remote control facilities. If LOCAL is selected read on from step 3.

3. Choose an appropriate range or AUTO range.

4. Press the AC MODE push-button.

5. Select SLOW or FAST RESPONSE depending on the low frequency limit required: SLOW for frequencies down to 20Hz or FAST for frequencies down to 100Hz. SLOW is not available in conjunction with AUTO. As soon as the voltmeter detects that SLOW and AUTO range have been selected it automatically goes to the FAST RESPONSE mode.

6. Connect the input lead to the unknown voltage source, red to signal high and black to signal low.

7. Press the 10/SEC push-button for repetitive measurement or, alternatively.

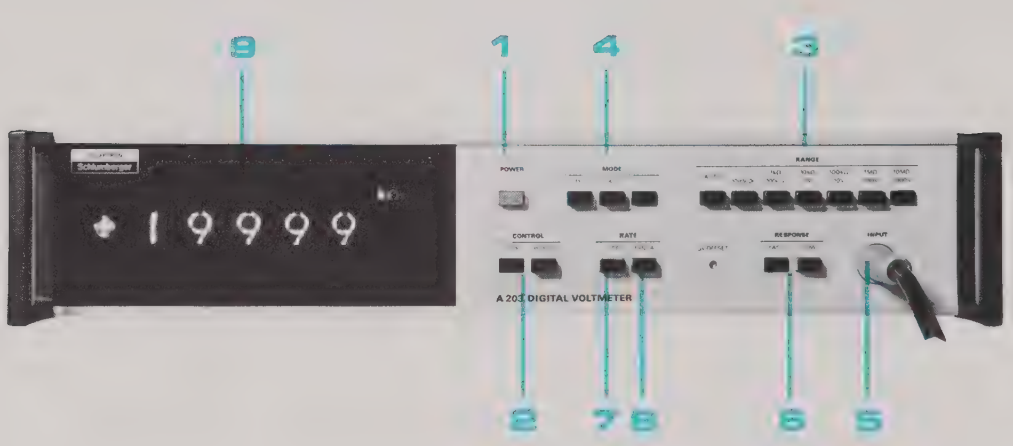
8. Press the MANUAL push-button for 'single shot' measurement.

   Note: If 10/SEC is selected the instrument displays the result of measurement ten times a second and it will be necessary to wait 1 second (FAST) or 5 seconds (SLOW), after connecting the signal to the input, for an accurate result.

   If MANUAL is selected the display is updated 1 second after pressing the button. During this time WAIT is displayed. For an accurate result if SLOW is selected, the input signal must be connected for 4 seconds before the button is pressed.

9. Read the voltage from the display and, if necessary, downrange to obtain greater sensitivity. The displayed reading is rms voltage assuming a sine wave input, using an A203 or A223. The A205 or A225 will read rms regardless of waveshape (within the limits of the specification).

## RESISTANCE MEASUREMENT




1. Switch POWER on.

2. Select LOCAL or REMOTE. If a fan out unit is fitted and REMOTE is selected see the section of this manual which covers remote operation, for a list and description of the remote control facilities. If LOCAL is selected read on from step 3.

3. Choose an appropriate range or AUTO range.

4. Press the Ω MODE button.

5. Connect the input lead to the unknown resistance.

6. Press the FAST RESPONSE button. Although SLOW RESPONSE can be used in the Ω mode, if resistances above 50kΩ are being measured the time constant of the filter is increased with a corresponding increase in the time taken for measurement.

7. Press the 10/SEC push-button for repetitive measurement, or alternatively,

8. Press the MANUAL button for 'single shot' measurement.

9. Read the resistance from the display, changing range if necessary.

## CURRENT MEASUREMENT

Although current measurement is not a facility provided by this voltmeter, it is easily effected by measuring the potential difference developed across a known precision resistance. The type of resistor used is important: for dc use either a precision wire wound component or, if available, a standard resistor; for ac use a metal film precision resistor.

Alternatively, the Solartron Current Adaptor EX3180, converts any of the voltmeters in this range to an AC/DC digital ammeter capable of measuring currents in the range 1nA to 2A. Full connecting details and operating instructions are given in the manual of the EX3180.

# SECTION 4 Measurement Techniques

The user who is only slightly familiar with the practice of precision measurement will find the *MASTER SERIES* of voltmeters very easy to use. The layout and logical operation of the controls, the information presented by the display and the connection of the unknown signal incorporate several new features that have not been provided in other digital voltmeters. This results in an instrument which is so simple that the totally inexperienced can take measurements confident that the control settings and the readings are correct.

The following notes are written for those who wish to know more about the techniques of precision measurement. They also provide a guide as to the best way of employing the voltmeter in more unusual measurement situations.

## INPUT RESISTANCE

In making a measurement of voltage virtually all instruments take a current from the source whose voltage is being assessed. The one exception is the true potentiometer in which, at balance, no current is taken from the source. The current taken by the measuring device gives a voltage drop across the internal resistance of the source so that the measured voltage is less than the true emf of the source (Fig. 4.1).

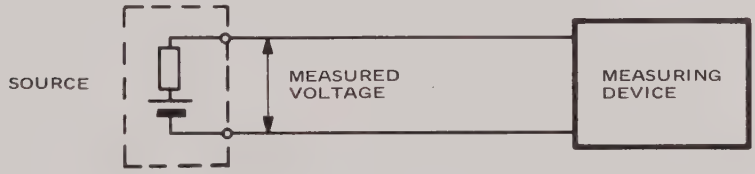



**Fig. 4.1** *Current taken by a measuring instrument can cause a voltage drop across source resistance.*

A good moving coil meter will take a current of 10μA (100kΩ/V) so that if the source resistance were 1kΩ the voltage drop would be 10mV. This would be pretty hopeless for 'precision' work since a voltmeter with such a low input resistance would read 1.4900V instead of 1.5000V.

Fortunately electronic feedback techniques can give a digital voltmeter such a high input resistance that in most practical work the effect can be ignored. Thus the A200 series, when measuring dc on the more sensitive ranges, has an input resistance in excess of 10GΩ (1GΩ on 10mV range). This means that the source resistance will have to exceed 1MΩ before an error of 1 digit is obtained. (See also effect of input current discussed later). This may sound a little vague; it is not possible to define the input resistance more closely because a group of voltmeters will have differing gains in their input amplifiers; although this has no effect whatever on the accuracy, the input resistance may be 20GΩ or 53GΩ but will never be as small as 10GΩ.

On the 100V and 1000V dc ranges it is not possible to apply the unknown input directly to the input amplifier; it must be first attenuated. The attenuator must be very accurate and stable and must withstand high input voltages, so wirewound resistors are employed. It is difficult and expensive to make the attenuator of very high value resistors, so a 10MΩ network is used. Hence, on the 100V and 1000V ranges the voltmeter input resistance is 10MΩ ±0.1%, and errors arising from source resistance can be calculated with reasonable accuracy. For example, on the two highest voltage ranges, a source resistance of 1kΩ will cause the result to be 0.01% low, i.e. by 1 digit in 10 000.

## INPUT CURRENT

All solid state devices are current operated hence the amplifiers of these voltmeters have a current flowing at the input terminals even when the input signal is zero. By careful design this current can be made almost insignificant and in fact is less than 100pA ($10^{-10}$A). During warm-up (for about 30 minutes after switch-on) the current will vary, since it has a temperature coefficient of approximately 2pA/$^{o}$C, and will then stabilise. Taking the input Hi terminal as a reference the current may flow into or out of this terminal and must therefore be regarded as lying between the values of +100 and -100pA.

It should be realised that the effects of input current are additional to the effects of input resistance. Thus, to take a ridiculous example, if on the 10mV range (A200, A203) a 10mV source is measured with a source resistance of 1MΩ the input resistance alone (1GΩ) would give a reading that is up to 10μV low. But an input current of 100pA will introduce an additional error of 100μV which can add to, or subtract from, the error due to input resistance. Thus, in this extreme example, there is uncertainty (rather than a defined error) which may lie anywhere from 110μV low to 90μV high (Fig. 4.2).

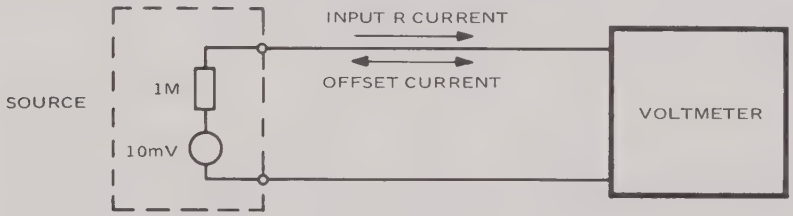



**Fig. 4.2** *Current taken by input resistance flows into the Voltmeter; offset current may flow either way. Both effects are present together.*

The conditions given in the above example will probably never be met by the average user because low level signals nearly always have a source resistance of less than 10kΩ, in which case the errors are insignificant. If in a rare situation a low level measurement must be made on a high source resistance the offset current can be monitored and reduced to a very low value in the following way (Fig. 4.3).

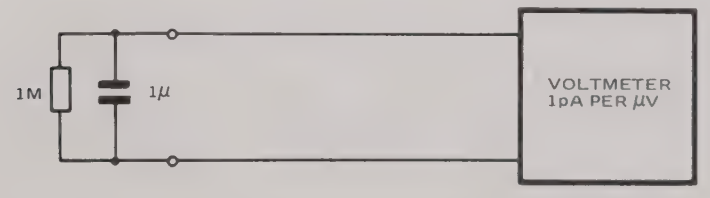
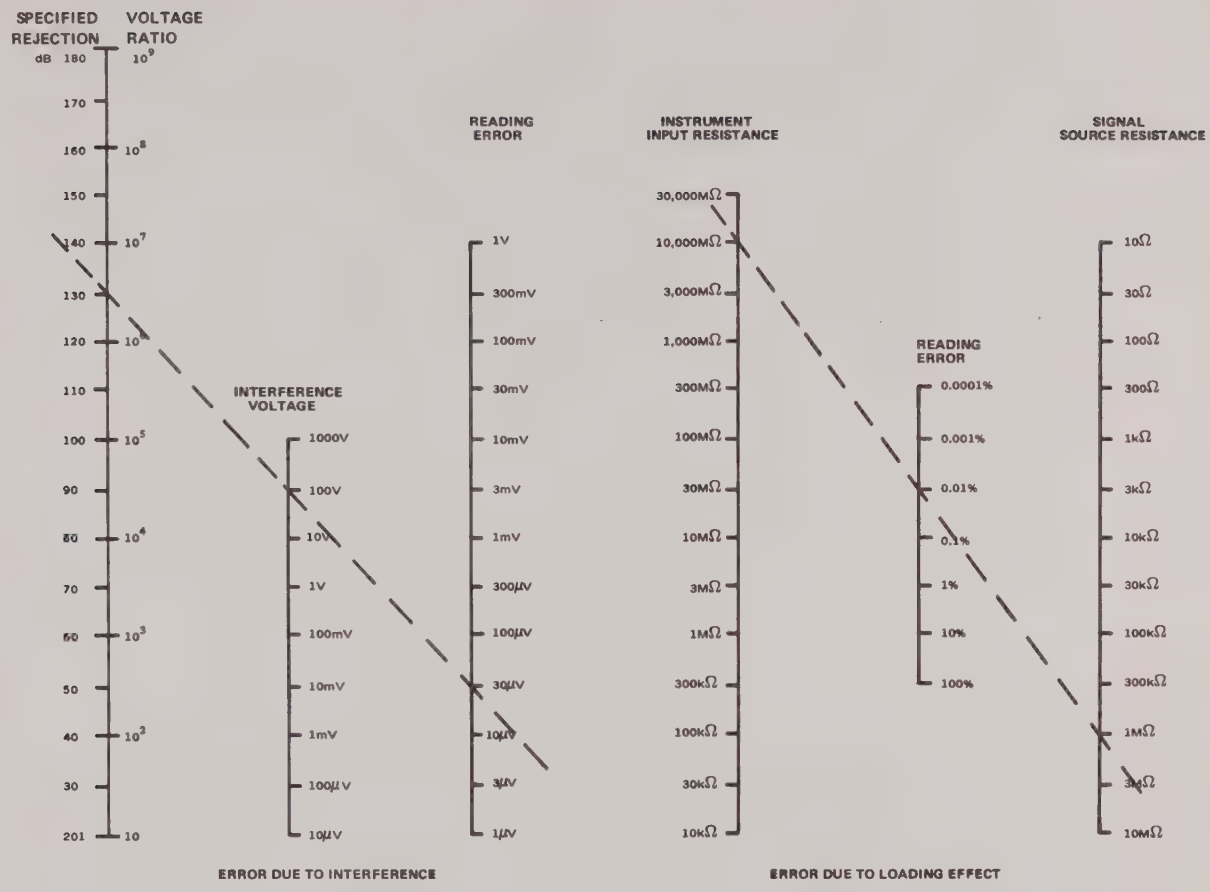



**Fig. 4.3** *Using a known resistor the voltmeter can measure its own offset current.*




Remove the top outer cover plate, switch on and allow the instrument to warm-up for 30 minutes. Connect across the input cable a 1M resistor in parallel with a low voltage 1μF capacitor – keep the connections short to minimise 50Hz pick-up. Allow a minute or two for thermal effects to disappear, with a short across the capacitor to dissipate any small dielectric storage; then remove the short circuit.

With the voltmeter on the 10mV range dc (A200, A203) the display represents 1pA per digit, while on the 100mV range (A220, A223) it is 10pA per digit. Through the top of the screened compartment on the right is a pre-set control called INPUT CURRENT which may be adjusted to bring the reading to almost zero. It probably will not stay at zero because very small drifts of a few pA are inevitable, but it will enable a measurement to be made on a high source resistance with less uncertainty in the short term. Over periods greater than a few hours, and with changes in ambient temperature, the current will drift by tens of pA. Hence the formal instrument specification only claims ±100pA for long term use.

## ASSESSING INPUT RESISTANCE

From the foregoing it will be realised that it is not possible to check the extremely high input resistance by using instruments as though it were a physical resistor. Furthermore the measurement is complicated by the presence of the offset current.

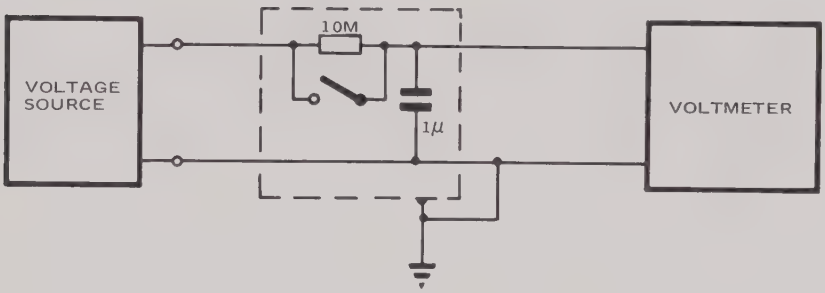



Fig. 4.4 *An assessment of input resistance will include an effect due to offset current.*

With the arrangement shown in Fig. 4.4 the components are mounted in a screening box which is bonded to earth in order to minimise 50Hz pick-up. The voltmeter is set to the 10V dc range and the voltage source to approximately 10V. The switch is first closed and the reading noted, (say 10.057). Upon opening the switch the reading will fall over a short period of time to, say 10.052. Ignoring the offset current this is a fall of 5mV in 10V, which is a factor of $2 \times 10^3$. So the input resistance is $2 \times 10^3 \times 10M\Omega = 20G\Omega$.

A proportion of the change will be due to offset current and this will become a greater proportion on the lower voltage ranges. So if any reasonable assessment of input resistance is to be attempted, the current should be first reduced to a few pA as described earlier. As a check the measurement can be made using each polarity of input voltage in turn. A difference in the readings taken with the $10M\Omega$ in circuit will then give a measure of the offset current.

The difficulty of an accurate assessment of input resistance on more sensitive ranges is the only reason why $1G\Omega$ is specified for the 10mV range. The value is probably in excess of $10G\Omega$, but it is impossible to measure it with any reasonable degree of certainty.

## SPURIOUS VOLTAGES

Although small emf's occur in the voltmeter input circuits they are compensated for during calibration. Thereafter, when the instrument has warmed-up for about 30 minutes, they are so stable as to be quite insignificant to the user. The drift in the input amplifier is equivalent to an input voltage change of approximately $1\mu V$ per week. The user therefore need not make any compensation or adjustment in order to achieve accurate results.

The voltmeter will faithfully measure any input that is applied to its terminals; it is the responsibility of the user to ensure that the input contains only the voltage that he wishes to measure. In low level work – with perhaps a few tens of microvolts – this may require some care and thought in the arrangement of the circuit.

As an example consider measuring the voltage produced by passing a very small current through a wirewound resistor. On the 10mV range the reading is recorded as $126\mu V$. But the resistor is placed – in the sun or near a power transistor – so that one end is a little warmer than the other.

Because of the dissimilar materials used in the wire of the resistor and in the copper connections a net thermal emf will exist of possibly 40$\mu$V/$^{o}$C. Thus a differential of 0.5$^{o}$C across the resistor could mean that the true result should be either 106$\mu$V or 146$\mu$V. The voltmeter cannot possibly distinguish between the wanted and unwanted parts of the signal that is applied to it. In this example, without altering the conditions of the resistor in any way, a measurement should be made with the small current flowing in each direction. In one case the thermal emf will add and in the other it will subtract. So the mean of the two results will eliminate the error.

Metal oxide resistors and reed relays are two other components in which thermal emf's can bring about similar errors. In the reed relay the heating of an operating coil may contribute to this and it may be desirable to employ two reed switches in the same coil so that, when connected in series, thermal emf's are self-cancelling. In the A200 range of voltmeters the reed assemblies, specially developed by Solartron, are used in circuits where these thermal effects are quite insignificant.

When the unwanted emf can be established and it is steady it can be backed off by using the $\mu$V ZERO control provided on the voltmeters. This has a range of $\pm$15$\mu$V.

In attempting precision measurement of low level signals effects other than thermal emf's can also cause problems. Leakage across an insulating material when degraded by high humidity or an industrial atmosphere may produce an unsuspected voltage across a source resistance. Coaxial cables when flexing under vibration can generate quite high transient voltages due to the screen scrubbing the polythene insulant; use low noise cables.

## SERIES MODE INTERFERENCE

The examples of thermal emf's given above can be regarded as forms of interference because they interfere with the accurate assessment of the unknown signal. They are in series with the signal and voltmeter input and represent a special case of series mode interference because there is nothing that the voltmeter can do towards rejecting dc interference while measuring a dc signal.

Series mode ac interference is a different matter. Because of their basic design principle these voltmeters will ignore all the usual forms of ac and noise that may be intermingled with the dc signal. Hence in all normal measurement work the user will be unaware of ac interference and it will not cause errors. Nevertheless it would be possible to introduce such a degree of interference that the voltmeter would be unable to cope, so the keen user may be interested in the mechanism that brings about rejection.

The most common form of ac interference is simple 'hum' – i.e. 50Hz superimposed on the dc signal. This can be visualised either as pick-up on the connecting leads, as shown in Fig. 4.5 (a), or as a generator that is a part of the source, as in Fig. 4.5 (b). In both the result is the same and is shown graphically in Fig. 4.6.

Fig. 4.5 *Interference at 50Hz can arise from pick-up on the leads (a), or may be inherent in the source (b).*

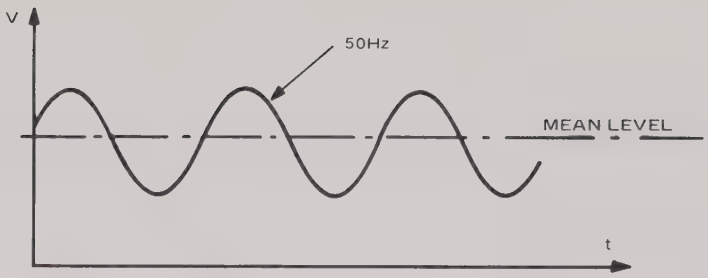



Fig. 4.6 *50Hz superimposed on the dc level that the voltmeter is trying to measure.*

Users of oscilloscopes will be familiar with this sort of picture and will know that the ac component is typically a few millivolts peak-to-peak. This may be superimposed on a wanted dc signal of a mere 100μV.

These voltmeters employ the dual-ramp technique which is described in the Principles of Operation.

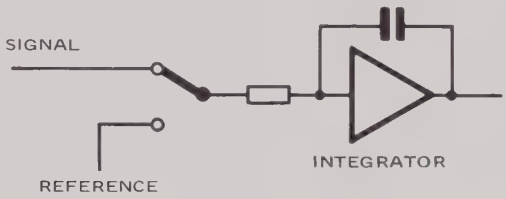



Fig. 4.7 *In the dual-ramp system the integrator is switched first to the signal (ramp-up) and then to the reference (ramp down).*

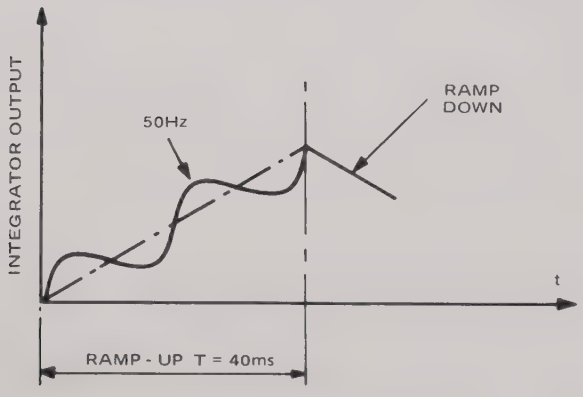



Fig. 4.8 *At the end of ramp-up the integral of any 50Hz component is zero.*

The integrator is connected to the input signal (actually to the output of the input amplifier) to start the initial phase of the measurement. This phase is called 'ramp-up' and lasts for a time that is defined by the frequency of the clock and the capacity of the counter. During ramp-up the output of the integrator is proportional to the integral of its input. If ramp-up lasts for T seconds then it is the integral of the input over T seconds that finally remains on the integrator

capacitor when the switch opens. It is this voltage that is assessed during ramp-down. When T is made equal to the period of the ac interference (or to any whole number of periods) the integral of the ac at the end of ramp-up will be zero. Thus ramp-down starts from a voltage that is proportional only to the dc component (actually to the mean level) of the input. Fig. 4.8 illustrates the situation for a particular case of 50Hz interference.

In this series of voltmeters the ramp-up time (T) is 40ms so that they inherently have rejection of 25Hz, 50Hz, 75Hz, 100Hz..... etc. This is shown by the curves of Fig. 4.9, where rejection notches occur every 25Hz, in which the rejection ratio is given in dB.

To digress for one moment – the decibel (dB) may be unfamiliar to some. It is used here to specify a voltage ratio. The relationship is:

Number of decibels = $20 \log_{10}$ (voltage ratio)

Example: Voltage Ratio = 1000

Number of dB = $20 \times 3 = 60$dB

| dB | Ratio | dB | Ratio |
|---|---|---|---|
| 1 | 1.1 | 9 | 2.8 |
| 2 | 1.3 | 10 | 3.2 |
| 3 | 1.4 | 20 | 10 |
| 4 | 1.6 | 40 | $10^2$ |
| 5 | 1.8 | 60 | $10^3$ |
| 6 | 2.0 | 80 | $10^4$ |
| 7 | 2.2 | 100 | $10^5$ |
| 8 | 2.5 | 120 | $10^6$ |

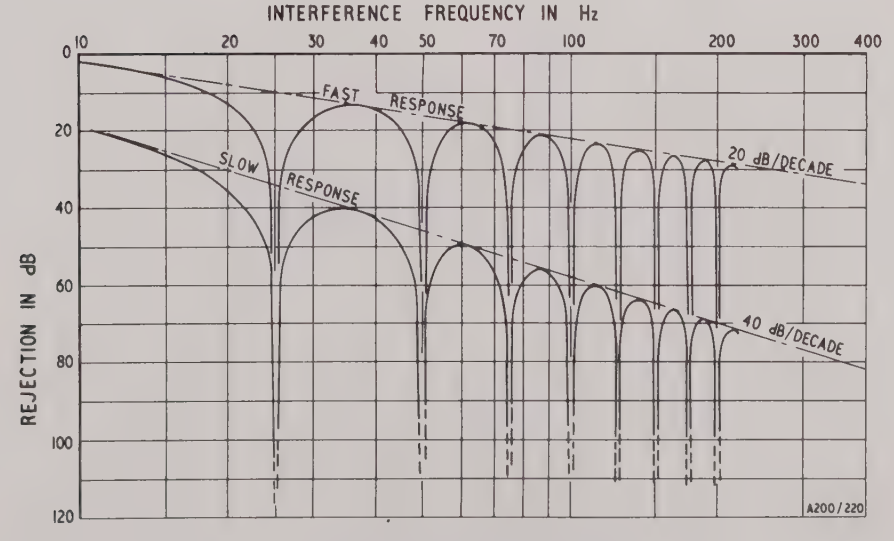



**Fig. 4.9** *SERIES MODE REJECTION*

*These curves show the rejection that is attained by A220 and A223 for interference with dc measurement at the frequencies given.*

*A200 and A203 have ramp-up time locked to the mains period so that the curves shift along the frequency axis in step with changes of mains supply frequency.*

Decibels add; but ratios must be multiplied. Thus:

$$36dB = 20 + 10 + 6dB$$

$$= 10 \times 3.2 \times 2 = 64 \text{ ratio}$$

If the ramp-up time were precisely 40ms there would be virtually infinite rejection of frequencies at multiples of 25Hz. But the clock frequency cannot be absolutely constant, and although this has no effect on measurement accuracy, the specified rejection must be less than infinite. Hence with A220 and A223 the rejection at 50Hz is better than 60dB; this means that any error will be, at worst, one thousand times smaller than the interference. Usually 50Hz interference arises from the supply mains and occasionally, when the national supply is heavily loaded, this will fall below 50Hz and the integration will be less than perfect. To allow for this as well as for small variations of clock frequency the A220 and A223 specify 36dB for 50Hz $\pm$1%.

Since the precise clock frequency has no effect on the accuracy of the result this frequency may be varied so that ramp-up time is always equal to two mains supply periods. A200 and A203 have a digital servo built in to do this and, as a result, the series mode rejection to mains interference is in excess of 70dB even though the supply frequency may vary by $\pm$2%.

## COMMON MODE INTERFERENCE

Interference can also arise from unwanted voltages which are common to both voltmeter leads. Consider Fig. 4.10 – here the signal source is earthed locally and the voltmeter input has also been earthed.

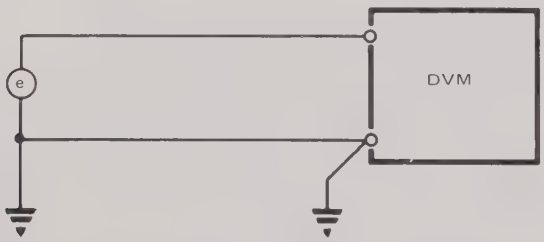



**Fig. 4.10** *An 'earth' at both source and voltmeter input may introduce common mode interference. For this reason the voltmeter input is fully isolated.*

There is a distinct possibility that the two 'earths' are not at a common 'zero' potential; in extensive industrial plants widely separated 'earths' can have as much as 10V between them. This situation is equivalent to that of Fig. 4.11 where the source is known to be at a finite potential with respect to earth.

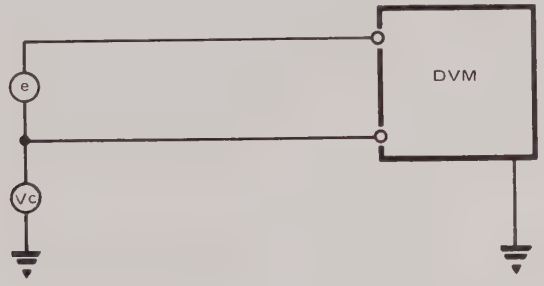



**Fig. 4.11** *The source can be at a high potential above earth without causing errors.*

For example, a thermocouple used to measure the temperature of a furnace element might be generating 1mV of dc signal while kept at 240V ac to earth. Obviously it would be ludicrous to earth the voltmeter input, although the chassis and most of the circuits are earthed via the mains supply lead.

All the voltmeters in this series have been engineered so that the input circuits are extremely well isolated from the chassis which is connected to mains earth. In all normal measurement work the small current which is driven down the leads to earth by a large common mode voltage will not cause any error. This voltage should be restricted to 500V purely to ensure safety for equipment and personnel.

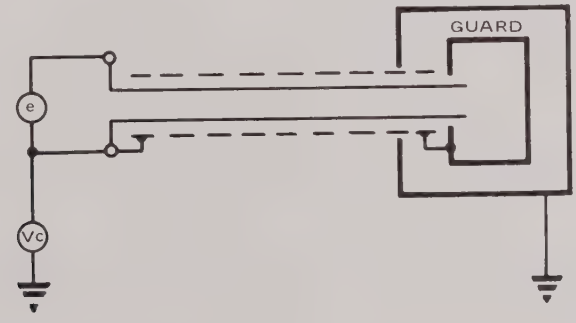



**Fig. 4.12** *In the lead provided with the voltmeter Guard is strapped to Lo (BLACK) within the free end of the cable.*

The lead supplied with each voltmeter is shown in Fig. 4.12. Within the instrument the cable screen is wired to the guard box and at the free end the screen is strapped to the black wire. Hence the guard is effectively preserved right up to the signal source and common mode current flowing in the screen and via leakage to earth cannot affect the measurement in any way.

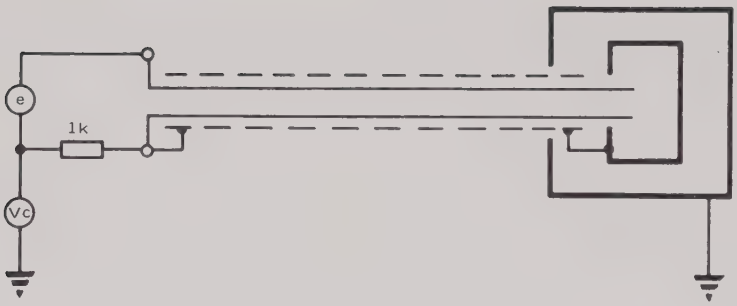



Fig. 4.13 *A rare, but more difficult, situation is where common mode current flows through lead resistance. This is entirely overcome by the arrangement of Fig. 4.14.*

In some measurement situations a common mode voltage can have an affect on the reading. Most users will never meet the problem, but those who do can still eliminate error by using the voltmeter correctly. When there is resistance associated with the source – perhaps inherent in the source, or in connecting leads – the common mode current can flow through this resistance. Examples are: the resistance of strain guages; long compensating leads from a thermocouple. This is illustrated by Fig. 4.13 where it will be seen that current flowing from Vc to earth down the screen must pass through the resistance. If the guard-earth leakage is assumed to be the specified minimum of $10^{10}\Omega$ and Vc is 100V dc the common mode current will be $10^{-8}$ A. Taking a lead resistance of 1k$\Omega$, $10^{-8}$ A will give a voltage drop of 10$\mu$V. Since the voltmeter cannot reject dc interference the worst error will be 10$\mu$V.

If the source of common mode is ac the stray capacitance from guard to earth is more important. The figure specified is 500pF, which is about 6M$\Omega$ at 50Hz. With Vc now 100V rms the drop across 1k$\Omega$ is approximately 17mV rms or 24mV peak. This appears at the input terminals and the inherent rejection of series mode will be effective in reducing reading error to much less than 24mV. With A200 or A203 the final reading error at worst will not exceed 8$\mu$V.

In these examples a 1k$\Omega$ resistance has been assumed in one lead. Obviously the magnitude of the error is proportional to this resistance and it is accepted practice to specify common mode rejection with 1k$\Omega$ unbalance in the leads using the configuration of Fig. 4.13. Even in these exceptionally adverse circumstances the errors can be overcome by using a different input arrangement as in Fig. 4.14.

This is provided by using a special lead EX3183 from which the 4 cores and the screen are brought out as separate terminations.

Fig. 4.14 shows the EX3183 adapted for three terminal measurements. Alternatively, the EX3193 (three terminals - signal high, signal low and guard) is available.

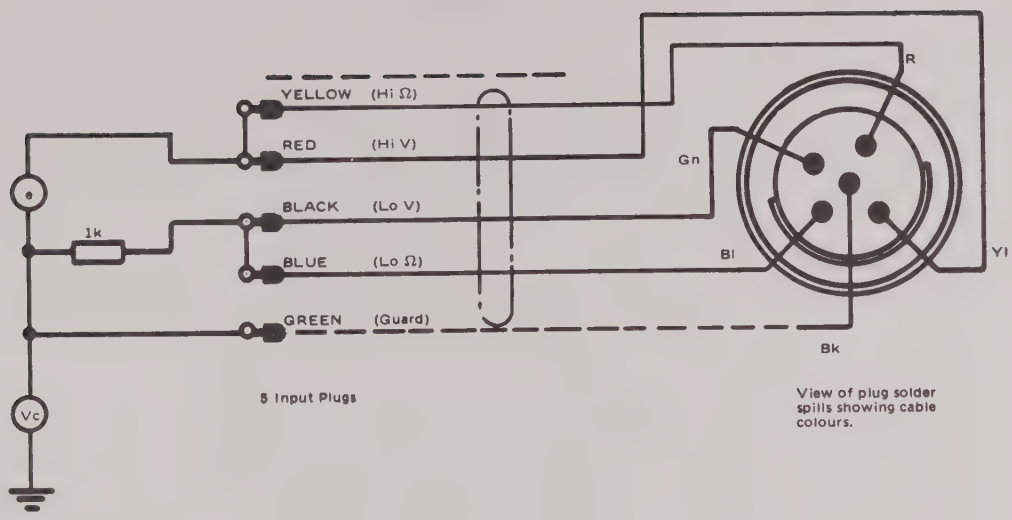



Fig. 4.14 *A special lead (EX 3183) is obtainable from Solartron which enables the Guard to be driven directly by the common mode voltage.*

The 4 cores are required for 4 terminal resistance measurement as described later. For fully guarded voltage measurement only 3 terminals are necessary – signal high, signal low and guard (screen). When on voltage ranges the YELLOW and BLUE cores are connected within the voltmeter to RED and BLACK. To prevent these plugs accidentally making contact with earth, or with other circuits and perhaps causing damage, the YELLOW should be plugged into RED, and the BLUE should be plugged into BLACK. GREEN is connected directly to the source of interference thus driving the guard at the common mode voltage and preventing common mode current flowing through the lead resistance. Using this arrangement, even though the interference were the maximum permitted (500V peak 50Hz), it is most unlikely that there would be any error discernable – even on the most sensitive range.

For a more complete treatment of interference in digital voltmeter measurements the reader is referred to:

1. 'Digital Voltmeters and Interference'
2. 'Principles of Interference Rejection'

both of which are available free on request to Solartron.

## NOISE

The foregoing explanation of interference rejection has dealt specifically with 50Hz because by far the most common source of interference is the mains supply, or fields radiated from mains wiring and mains energised equipment. The curves of Fig. 4.9 show that at higher harmonics of 25Hz rejection is improved so that 100Hz ripple from power supplies or 400Hz aircraft and ship supplies are unlikely to introduce difficulty. When considering general 'noise' of no specific frequency the integration process inherent in the dual-ramp technique still applies. The resultant noise component over 40ms integration will tend to zero.

## FILTERS

For all normal dc measurement the use of the filter which is built into the voltmeter (SLOW) is unnecessary. Although the increase in response time would be of no consequence during laboratory work, the delay may be of significance in data logging or in automatic test systems. In

these cases the use of FAST will give adequate interference rejection. In rare situations the interference may be so excessive that SLOW produces some benefit on dc measurement. This can be established by changing from FAST to SLOW and observing if there is a difference in reading. If there is a difference SLOW gives the correct answer.

## AC VOLTAGE

The unadorned digital voltmeter is able to measure dc voltage only. It can be adapted to measure ac by including an ac-dc converter ahead of the dc input circuits. This has been done in the *MASTER SERIES.*

A203 and A223 include a converter which may be regarded as a sophisticated full-wave rectifier. By including semi-conductor rectifiers in an operational amplifier loop non-linearities in the transmission characteristics of the rectifiers are eliminated. The smoothed output of such a rectifier system is a dc level which is proportional to the *mean* value of the ac; it is this which is passed to the dc voltmeter for measurement. Fig. 4.15 shows this action.

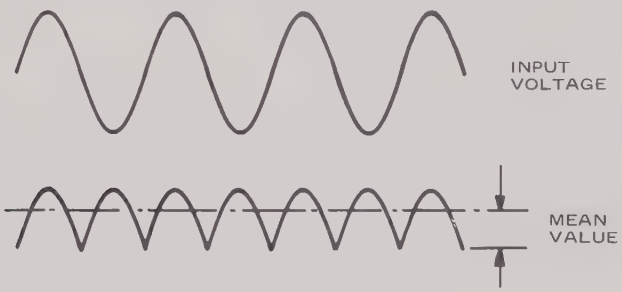



**Fig. 4.15** *An ac input voltage is rectified in the ac-dc converter and the smoothed mean value is passed to the dc circuits for measurement. Although the mean value is sensed the rms value is indicated.*

There are three ways of specifying the amplitude of an ac voltage: the mean; the peak; the root-mean-square (rms). For any periodic function there is a precise relationship between these which can be calculated. In the case of a sine wave:

$$\text{Mean} = \frac{2}{\pi} \text{ peak}$$

$$\text{rms} = \frac{1}{\sqrt{2}} \text{ peak}$$

When speaking of ac voltages (e.g. 240V) it is an accepted convention that the rms value is understood unless mean value or peak value is stated. The rms is also used in most calculations. It has therefore become accepted that a measuring instrument will read rms, although the vast majority actually measure the mean. For these reasons A203 and A223 are scaled to give a reading of the rms of the input on the assumption that the input is a perfect sine wave.

Distortion is a factor which can occasionally introduce errors as a result of this assumption. The reader will be familiar with the analysis of a complex waveform which breaks down a periodic function into a fundamental sine wave plus a series of harmonics. It is the harmonics which represent the distortion content, the degree of distortion being dependent upon the order,

the amplitude and the phase of the harmonics. It will be extremely rare that the detailed harmonic content is known, but what may be known is the Total Distortion which is, in effect, the sum of the total harmonic content. Measurement errors would be greatest for a mean sensing rms indicating instrument is the total distortion was all third harmonic. Hence this assumption would enable an estimate to be made of the worst possible errors. In this case:

$$\text{Max percentage error} = \frac{1}{3} \text{ total percentage distortion.}$$

Thus a total distortion of 0.3%, if all third harmonic, could give a worst error of 0.1%.

The voltmeter input impedance on ac is either 1MΩ or 10MΩ (depending on range) in parallel with a capacitance. At frequencies above a few tens of Hz the capacitive term will be dominant. The values are given in the formal specification and may be used to calculate the voltage drop across a source impedance at a particular frequency.

Consideration of Fig. 4.15 will show that the lower the signal frequency the more smoothing is necessary before the mean level can be passed into the dc measuring circuits. Therefore below about 100Hz a longer time constant filter (SLOW) is required in order to preserve measurement accuracy. AC measurement with a digital voltmeter gives easily the best compromise between speed and accuracy over all other forms of ac measurement. But with low frequencies, using any measurement technique, the reading must have time to settle.

It has been pointed out that when measuring dc voltages the voltmeter cannot reject thermal or other dc interference. In exactly the same way there cannot possibly be rejection of series mode ac interference when measuring ac voltages. Common mode rejection is, however, still preserved, and the input circuits on ac are still fully isolated from chassis and from earth. For those who are interested in pursuing the subject in greater depth a paper on AC Voltage Measurement, with particular reference to waveform errors, is available free on request to Solartron.

## RESISTANCE

Voltmeters A203 and A223 measure the value of a resistor by passing a defined current through the resistor and determining the potential difference that results. The current is small (600μA on 1kΩ range) so that power dissipated in the resistor is minimised. In measuring low values of resistance the voltage dropped along the current carrying leads can sometimes introduce errors. In these instruments, when using the lead provided, the effect is entirely eliminated by operational amplifier techniques within the voltmeter.

The most sensitive resistance range of 1kΩ with its 100mΩ sensitivity is satisfactory for most low value measurements. Should there be a requirement for increased sensitivity on low values the voltmeter can be used on a dc voltage range to measure the potential difference across the resistor with a current provided from an external source (Fig. 4.16).

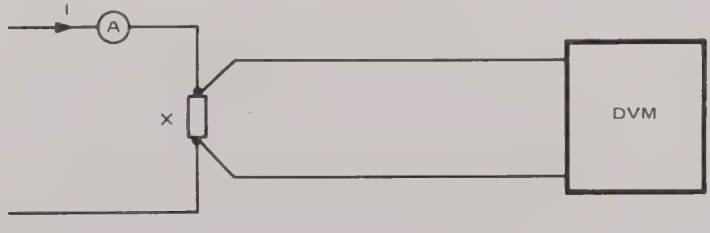



**Fig. 4.16** *A very low value resistance may be measured by measuring the voltage devloped across it. The voltage leads should be connected close to the ends of the resistor.*

If I is 1mA and the voltmeter is on the 10mV dc range a reading of 12.631mV means that $x$ is 12.631Ω. Obviously other appropriate currents and voltage ranges could be used. The first point to observe is that, in this example, the sensitivity is 1mΩ per digit. Hence the voltmeter connections must be made right at the ends of the resistor and must not embrace any significant length of the current carrying leads (10cm of 22SWG copper wire is approximately 4mΩ).

A second point is that the accuracy is affected directly by the precision of the current setting. There would be little point in using a moving coil multimeter to set current and then record a reading of 12.631Ω.

An improved technique is shown in Fig. 4.17.

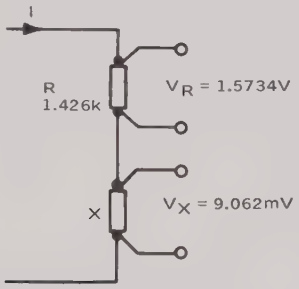



Fig. 4.17 *A ratio measurement avoids having to set a precise value of current.*

Here a resistor R, whose value is known, is connected in series with the low value unknown $x$. R can be a much higher value than $x$. If R is not already known it can be measured on one of the ohms ranges. The voltmeter, on dc auto-range, is connected across R and the current supply is adjusted to give a reading greater than half full-scale. The precise value of $V_R$ is not important; neither is the value of the current I. In this example I could be simply provided by a 1.5V dry cell. The reading $V_R$ is recorded. The voltmeter is transferred to $x$ and the reading $V_X$ is noted. The value of $x$ is then given by:

$$x = R \frac{V_X}{V_R} \text{ ohms}$$

Using the values shown in Fig. 4.17:

$$x = \frac{1.426 \times 10^3 \times 9.062 \times 10^{-3}}{1.5734} = 8.213\Omega$$

If $x$ is being set to different values it may be necessary to measure $V_R$ each time because, unless I comes from a constant current supply, changes of $x$ may significantly alter I.

Should it be necessary to measure resistance at a distance from the voltmeter which is beyond the reach of the standard input lead, a special lead EX 3183 may be obtained from Solartron. In this the four cores and screen are terminated separately, as shown in Fig. 4.18. This cable should be extended to reach the point of measurement by means of a similar 4 core screened cable, and connected to the remote resistor as shown.

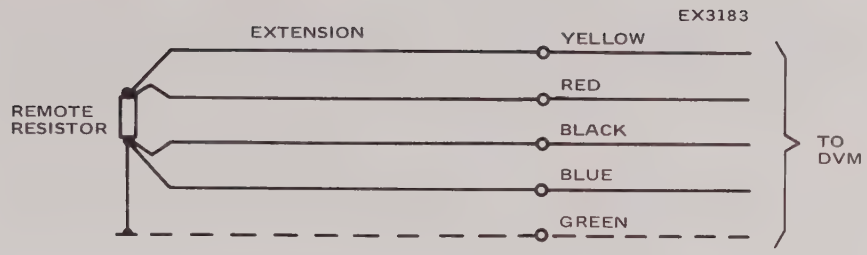



Fig. 4.18 *In measuring a remote resistor, lead compensation can be preserved by using the special input cable (EX 3183, obtainable from Solartron) and extending it by a 4 core screened cable.*

This arrangement will preserve the compensation for lead resistance on any ohms range up to a maximum of 1Ω per wire. Using an extension of 7/.0076 wires a length of 100m can be safely used.

## CURRENT

For determining current (dc or ac) the voltmeter can be used to measure the voltage drop when the current is passed through a known resistor and the value of the current thereby calculated.

If currents of the same order are to be measured frequently, the provision of a resistor of suitable value can save the chore of calculation. For example with a 1Ω resistor and the voltmeter on the 1V range currents up to 1.9999A can be determined by direct reading amps instead of volts. If the results are to be consistent with the accuracy of which the voltmeter is capable the resistor must be known precisely. This can be achieved by taking a value that is slightly high and wiring others in parallel while measuring the total value as described earlier. The main resistor should be a precision type capable of good stability; wirewound is suggested for dc work, but for ac measurement metal film resistors should be used to avoid inductance effects.

In applications where a wide range of currents are to be measured the Current Adaptor EX 3180 should be considered. This has precision resistors built-in. When used with a Voltmeter in the *MASTER SERIES* current ranges of 1A down to 10μA can be selected by push buttons giving a maximum sensitivity of 100pA.

## LONG TERM INTEGRATION

In measuring a steady dc input the number of pulses gated to the counter during ramp down is the measure of the input voltage. If this number of pulses is $p$:

$$p \propto \text{input voltage}$$

actually $$p \propto \frac{1}{T}\int_0^T v(t)dt$$ where $v(t)$ is a varying input

$T$ is ramp-up time

or $$p \propto V \text{ where } V = \frac{1}{T}\int_0^T v(t)dt$$

On a given range each single pulse results in 1 digit in the display, and the value of 1 digit depends upon the range. Thus if 1 digit represents $S$ volts (Sensitivity), $p$ digits (i.e. $p$ pulses) represents $pS$ volts.

But on A200 and A220 display at nominal range is 10 000.

Thus $S = R \times 10^{-4}$ where $R$ is nominal range value in volts.

(e.g. on 100mV range, $S = 100 \times 10^{-3} \times 10^{-4} = 10\mu V$).

Then $V = pR \times 10^{-4}$ for each individual reading.

If N readings are taken: $V = \frac{Np}{N} R \times 10^{-4}$

But $Np$ is the total pulses accumulated during $N$ measurements.

Put $Np = P$

Then $V = \frac{P}{N} R \times 10^{-4}$

In a time $t$ secs there are $10t$ readings, so $N = 10t$:

$$V = \frac{P}{10t} R \times 10^{-4}$$

$$V = P \frac{R \times 10^{-5}}{t} \text{ volts}$$

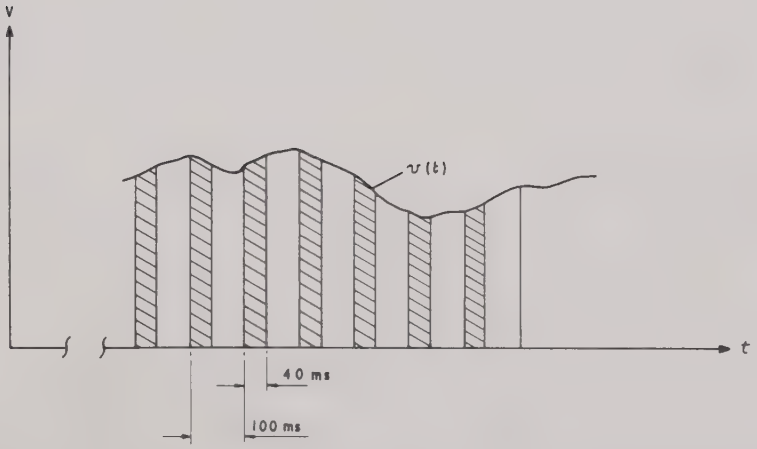



**Fig. 4.19** *Long term averaging process*

As ramp-up lasts for 40ms a long term measurement is the result of repeatedly taking the average value over 40ms in each 100ms (Fig. 4.19). Thus the final average value will be correct only when the variations in the input are slow relative to 100ms. This is exactly the situation in which long term averaging is required – for example, gradual variations in a chemical plant. Obviously it is valid only when the input is continuously of one polarity, since the gated pulses do not contain polarity information.

Thus a long term average of a slowly changing input may be obtained by taking the output from pin k on the fan-out unit to an external counter.

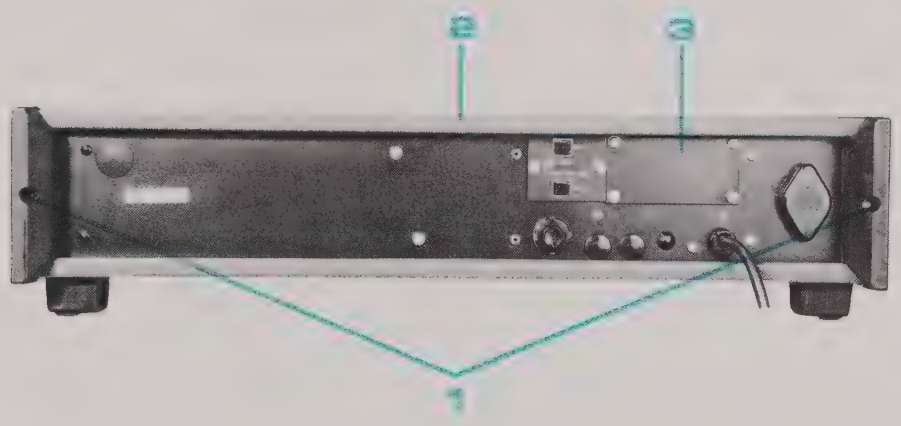
$$\text{Average} = \frac{\text{total count x nom. range in volts}}{\text{count time in seconds}} \times 10^{-5} \text{ volts.}$$

# SECTION 5 Data Systems Use

## SYSTEMS USE

The addition of a fan-out unit makes this voltmeter eminently suitable for use in a data logging or automatic test system. It enables full remote control of all the front panel functions (except power) and provides display information and the various control signals necessary in such systems.

## INSTALLATION OF FAN-OUT UNIT A204



1. Release the two side panel captive securing screws and withdraw the side panels.
2. Remove the top cover.
3. Remove the blanking plate.
4. Insert the fan-out unit into the connector provided and, using the blanking plate screws, secure the fan-out socket to the rear panel.
5. Replace the top and side covers and secure.

## RACK MOUNTING

Included with the accessories is a pair of combination handles/rack mounting ears for substitution with the standard handles. This is effected by removing the four handle retaining screws and the handles, and replacing with the rack ear/handles using the same screws.

In addition, if space is required between instruments within the rack for rack runners, it is necessary to remove the lower side panel retaining strips and the bottom cover, as follows:-

1. Release the rear feet.

2. Slide out the side panels.

3. Remove the lower retaining strips.

4. Remove the bottom cover.

The side panels may be replaced.

## FAN-OUT FACILITIES (at rear socket)

| PIN | FUNCTION | PIN | FUNCTION |
|---|---|---|---|
| A | $1 \times 10^0$ | d | Polarity + |
| B | $2 \times 10^0$ | e | Polarity – |
| C | $4 \times 10^0$ | f | 1 BCD |
| D | $8 \times 10^0$ | h | 2 Range Information |
| E | $1 \times 10^1$ | j | 4 (See Output Information) |
| F | $2 \times 10^1$ | k | Gated Clock |
| H | $4 \times 10^1$ | m | 1 BCD |
| J | $8 \times 10^1$ | n | 2 Range Command |
| K | $1 \times 10^2$ | p | 4 (See Remote Command) |
| L | $2 \times 10^2$ | r | Command CONTROL (LOCAL/REMOTE) |
| M | $4 \times 10^2$ | s | Contact Sample |
| N | $8 \times 10^2$ | t | Pulse Sample |
| P | $1 \times 10^3$ | u | Print Command (Pulse) |
| R | $2 \times 10^3$ | v | Print Command (Level) |
| S | $4 \times 10^3$ | w | Data is Changed (See Remote Command) |
| T | $8 \times 10^3$ | x | Data can Change (See Output Information) |
| U | $1 \times 10^4$ | y | Command AUTO range |
| V | | z | Command RESPONSE (FAST/SLOW) |
| W | | AA | Command MODE (DC, AC or Ω) |
| X | | BB | (A203 and A223 only) |
| Y | | CC | MODE Identification |
| Z | | DD | (A203 and A223 only) |
| a | | EE | |
| b | | FF | |
| c | | HH | 0V |

Staticised Display Information BCD

## REMOTE COMMANDS

Remote control of the instrument is possible only when Fan-Out Unit A204 is fitted. Before applying remote commands to the instrument, REMOTE must be selected either electrically (at pin r of A204) or by the front panel switch.

**Input Levels**

Level '1' is $+2.4V < \text{'1'} < +6V$ at $100\mu A$ or open circuit

Level '0' is $-0.5V < \text{'0'} < +0.5V$ at 5mA sink

**CONTROL**

| CONTROL | Pin r |
|---|---|
| LOCAL | 1 |
| REMOTE | 0 |

Note: If LOCAL is commanded whilst the REMOTE switch is in, then the only switches under LOCAL control are POWER and RATE.

**RANGE**

Ranges are selected by addressing pins m, n and p with 1, 2, 4 B.C.D. If the decimal value of the range code is 'N' then the full scale (nominal) commanded is:

$1 \times 10^{-N}$ kV (A200, A203, A220, A223)

or $1 \times 10^{(1-N)}$ MΩ (A203, A223)

depending on the MODE selection.

| Voltage Range | Range Code | | | N | Resistance Range |
|---|---|---|---|---|---|
| | p (4) | n (2) | m (1) | | |
| 1000V | 0 | 0 | 0 | 0 | 10MΩ |
| 100V | 0 | 0 | 1 | 1 | 1MΩ |
| 10V | 0 | 1 | 0 | 2 | 100kΩ |
| 1V | 0 | 1 | 1 | 3 | 10kΩ |
| 100mV | 1 | 0 | 0 | 4 | 1kΩ |
| 10mV (A200 A203 only) | 1 | 0 | 1 | 5 | — |

Note: If 101 is applied when either AC or Ω is selected or for A220 and A223 the 100mV or 1kΩ range will be called.

If 110 or 111 is applied the 1000V or 10MΩ range will be called.

**MODE**

Available on A203 and A223 only.

| MODE | Pin AA | Pin BB |
|---|---|---|
| DC | 1 | 1 |
| AC | 0 | 1 |
| Ω | 1 | 0 |

**AUTO RANGE**

Auto range is selected by Level 0 at pin y.

**RESPONSE**

| RESPONSE | Pin z |
|---|---|
| FAST | 1 |
| SLOW | 0 |

**RATE**

**Manual:** If MANUAL has been selected by the front panel control, the instrument need not be in the REMOTE mode to be able to initiate measurements by pulse or contact sample.

If 10/SEC has been selected by the front panel control, either MANUAL must be selected or REMOTE control commanded by a 0 level at pin r of the rear socket before pulse or contact sample can be used to initiate a measurement.

If REMOTE has been selected by the front panel control, the MANUAL control must also be pressed once (to release 10/SEC button) before measurements can be initiated by pulse or contact sample.

**Contact Sample:** Contact closure between pins s and 0V (HH) with less than 2ms contact bounce.

**Pulse Sample:** Positive pulse at pin t of $>10\mu s$ duration and between +3V and +8V amplitude.

Pulse or Contact sample can be applied any time while Print Command Level is at '1' but preferably not earlier than 5ms after new range/mode/channel selection.

**Repetitive:** Press the REMOTE and 10/SEC push buttons but do *not* command REMOTE. Then the remote control of other functions is retained.

To change from continuous to pulse or contact sample, command REMOTE by 0 level at pin r.

### DATA IS CHANGED

This input enables the user (system) to instruct the voltmeter that a settling time is required before the next measurement, because of a change of range and/or mode command data.

If command data is unchanged apply '0' at pin w

If command data is changed apply '1' at pin w

If the new command data is different, the '1' must be applied after DATA CAN CHANGE has gone to '0' and before SAMPLE (Pulse or Contact) command; this '1' must be maintained until DATA CAN CHANGE next goes to '0'. Thus, when the command data is different the internal digitise command will occur 10ms after SAMPLE command, whereas if it is unchanged the internal digitise command will occur 1ms after SAMPLE command.

## OUTPUT INFORMATION

Output Levels: Level '1' is +2.4V <1 <+6V from 6kΩ source

Level '0' is -0.5V <0 <0.5V at 10mA sink

### RANGE

There are two possible range output codes; Code 1 is identical to the range command code whilst Code 2 simplifies the interpretation of the output data, allowing the value to be read as; Reading (as an integer) x $10^{-N}$ V or kΩ. This effectively means that the range number, N, fixes the decimal point N places from the right of the measurement data and allows the value to be read in volts or kilohms.

The code is set by a single link on pcb No. 27 of the Fan-Out. Code 2 is normally connected before dispatch except when the dvm is supplied with a Compact - 33 Logger. To change to code 1 locate pins A, B and C at the bottom of pcb No. 27. If A and B are linked Code 2 is connected. The link should be moved to connect pins A and C for Code 1.

**Code 1** (as Range Command)

| Voltage Range | Range Output Code | | | N | Resistance Range |
|---|---|---|---|---|---|
| | j (4) | h (2) | f (1) | | |
| 1000V | 0 | 0 | 0 | 0 | 10MΩ |
| 100V | 0 | 0 | 1 | 1 | 1MΩ |
| 10V | 0 | 1 | 0 | 2 | 100kΩ |
| 1V | 0 | 1 | 1 | 3 | 10kΩ |
| 100mV | 1 | 0 | 0 | 4 | 1kΩ |
| 10mV | 1 | 0 | 1 | 5 | -- |

Value = Reading (as an integer) x $10^{-(N+1)}$ V or x $10^{-N}$ kΩ

**Code 2 Voltage Range Output:**

| Voltage Range | Output Code | | | N |
|---|---|---|---|---|
| | j (4) | h (2) | f (1) | |
| 1000V | 0 | 0 | 1 | 1 |
| 100V | 0 | 1 | 0 | 2 |
| 10V | 0 | 1 | 1 | 3 |
| 1V | 1 | 0 | 0 | 4 |
| 100mV | 1 | 0 | 1 | 5 |
| 10mV | 1 | 1 | 0 | 6 |

Formula = Reading (as an integer) x $10^{-N}$ Volts

**Code 2 Ohms Range Output:**

| Ohms Range | Output Code | | | N |
|---|---|---|---|---|
| | j (4) | h (2) | f (1) | |
| 10MΩ | 0 | 0 | 0 | 0 |
| 1MΩ | 0 | 0 | 1 | 1 |
| 100kΩ | 0 | 1 | 0 | 2 |
| 10kΩ | 0 | 1 | 1 | 3 |
| 1kΩ | 1 | 0 | 0 | 4 |

Formula = Reading (as an integer) x $10^{-N}$ Kilohms

**MODE**

| MODE | Pin CC | Pin DD |
|---|---|---|
| DC | 0 | 0 |
| AC | 1 | 0 |
| Ω | 0 | 1 |

**POLARITY**

| Polarity | Pin d | Pin e |
|---|---|---|
| Positive (+) | 1 | 0 |
| Negative (−) | 0 | 1 |

AC and Ω indication is the same as positive polarity. This information is staticised.

**OVERLOAD**

| Condition | Pin c |
|---|---|
| Not overloaded | 0 |
| Overloaded | 1 |

**PRINT COMMAND**

Level: In "repetitive" (10/SEC) mode, pin v is at 0. In MANUAL pin v is at 1 except during digitisation when pin v is at 0.

Pulse: At the end of ramp down, a positive pulse (from 0 to 1) at pin u of duration 10μs.

In the instances where the voltmeter requires an extra settling time (as indicated by the WAIT light on the front), Print Command is not generated until after the required WAIT time. Thus, Print Command incorporates the WAIT facility to indicate that the display has not been updated with the result of the latest measurement.

**DATA CAN CHANGE**

This signal instructs the user (data system) that new Range or Mode command data can be applied.

| Data Can Change | Pin x |
|---|---|
| Yes | 0 |
| No | 1 |

**GATED CLOCK**

Pin k presents the clock pulses which are counted during ramp down.

## OPERATING SPEED

The most important factors which govern the speed at which a data logging system can run are:

1. The delays introduced by the input scanning device.

2. The voltmeter digitisation time.

3. The time taken by the output device to record the reading.

Additionally, off-limit detection will introduce a delay.

**Scanner Delays**

These consists of the "sample command delay" and the "break before make gap". The sample command delay is the period between the moment a scanner relay is called and the moment sample command (Pulse or Contact Sample) is given. The break before make gap is the time between the release of one channel and the calling of the next; this is incorporated to ensure that no two channels are ever connected in parallel.

**Digitisation Time**

This depends on the following factors:

i) Time between start of integration and when the reading is available. For fixed range operation this time is between 40 and 80ms, depending on the reading.

ii) Internal delays introduced to give extra settling time if the commanded data is changed (10ms) or SLOW is commanded (approximately 1s).

iii) When the sample command is issued relative to the conversion cycle. On A200 and A203 integration starts only at every 5th cycle of the mains supply frequency, thus a delay of up to 100ms can occur before integration. Although A220 and A223 are not mains locked the time between integrations is the same.

iv) In addition, if AC SLOW is commanded, the sample command delay must be at least 4s to allow the input circuits to settle before a sample command is given.

Thus the maximum digitisation times for fixed range operation are:

| | |
|---|---|
| DC FAST | $\geqslant$ 180ms* |
| DC SLOW | $\geqslant \triangleq$1.2s |
| Ω FAST | $\geqslant$ 180ms* |
| Ω SLOW | $\geqslant \triangleq$1.2s |
| AC FAST | $\geqslant \triangleq$1.2s |
| AC SLOW | $\geqslant \triangleq$1.2s+ |

*plus 10ms if commanded data is changed.

+plus 4s extra settling time that must be included in the sample command delay.

If auto ranging is used the times as given in the specification apply.

### Recording Time

The time taken by an output device to record a reading may or may not affect the system speed. If the recording device has a built in staticiser (a buffer which stores the result), then the reading can be transferred almost instantaneously. This enables the voltmeter to be released for digitisation of the next measurement while the previous result is being recorded, (provided the recording time does not exceed 60ms).

More common, however, are the serial recording devices with which the time taken depends upon the number of characters to be recorded. For the recorders normally used by Solartron, the nominal times are:

| | |
|---|---|
| Addo X Printer | 55ms per character +350ms |
| Clary 35 Printer | 60ms per character +150ms |
| IBM 'B' Typewriter | 100ms per character +500ms approx. per new line |
| ASR 33 Teleprinter | 100ms per character |
| Addo 5 Punch | 55ms per character |
| Facit 4070 Punch | 13.3ms per character |
| DD110 Punch | 9ms per character +9ms |
| RDL 10000 Tape Recorder | 1ms to 2.5ms per character (depending on packing density) |

## HIGH SPEED REMOTE CONTROL

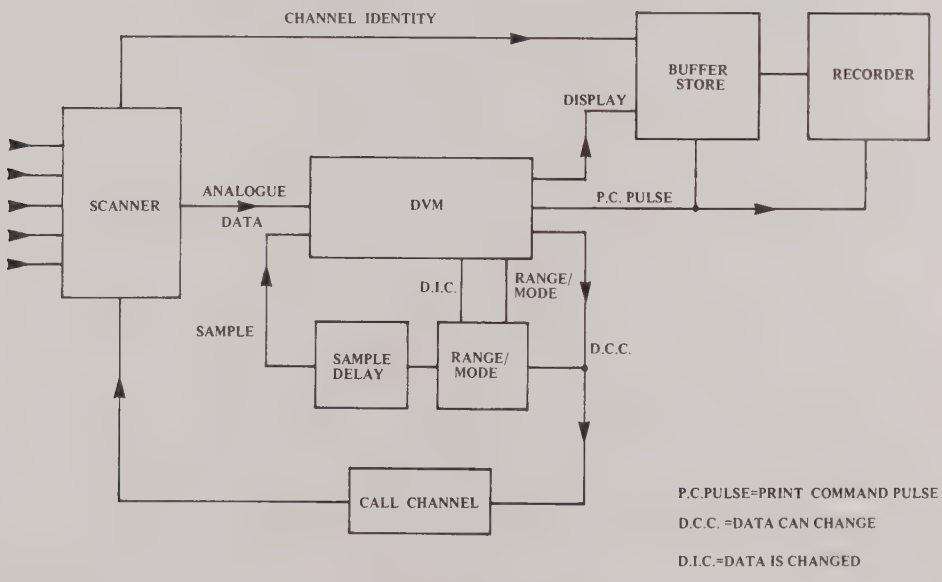



**Fig. 5.1 Basic Logging System**

Figure 5.1 shows a typical arrangement of a digital voltmeter (dvm) controlled externally in a data logging system. In this example, the recording device must be capable of completing the record within 60ms so that the system can operate at 10 channels per second, the fastest possible recording speed. The dvm measures sequentially the voltages from a number of input channels. The range and mode information is pre-programmed and may change from one channel to the next.

The operation is as follows: with the first channel connected to the dvm a sample is manually initiated (by either the MANUAL button or CONTACT SAMPLE for example); PRINT COMMAND goes low (DATA CAN CHANGE goes high) and the dvm measures the input starting at the first available complete conversion cycle. At the end of measurement the following occurs:

i) PRINT COMMAND goes high to initiate the transfer of the display information into the buffer/store.

ii) DATA CAN CHANGE goes low a) to enable a Range and/or Mode change if it is required, b) to command the application of the next channel.

If the new Range and/or Mode is different from the previous measurement DATA IS CHANGED must be taken high to increase the internal delay thereby giving the extra settling time required.

When the next channel is connected the sample delay is initiated. This delay ensures that the scanner relay contacts have settled. At the end of the sample delay PULSE SAMPLE is generated to instruct the dvm to start measurement of the new channel.

The timing of these events, shown in figure 5.2, is critical and is governed by the following rules:

i) PULSE SAMPLE: This must occur not earlier than 5ms after selection of range/mode/channel whichever is the latest.

For the highest recording rate (10 channels per second) the latest time that PULSE SAMPLE can be generated (assuming the worst case when the previous reading was full scale) is:

either approximately 10ms(*) after PRINT COMMAND (and DATA CAN CHANGE) if DATA IS CHANGED is high (data changed)

or is approximately 19ms(*) after PRINT COMMAND (and DATA CAN CHANGE) if DATA IS CHANGED is low (data not changed).

* The exact period is determined by the clock frequency which for A200 and A203 is fixed by the mains supply frequency.

Hence the sample delay must be >5ms and the break before make gap plus the sample delay must not exceed 10ms (or 19ms).

If AC and SLOW are commanded the sample delay must be increased by 4s to allow sufficient settling time.

ii) DATA IS CHANGED: This command must be applied after PRINT COMMAND has gone high (DATA CAN CHANGE has gone low) and before PULSE SAMPLE, and must be maintained until DATA CAN CHANGE next goes low.

Normally, as in the system described, DATA IS CHANGED would be coincident with the new channel selection.

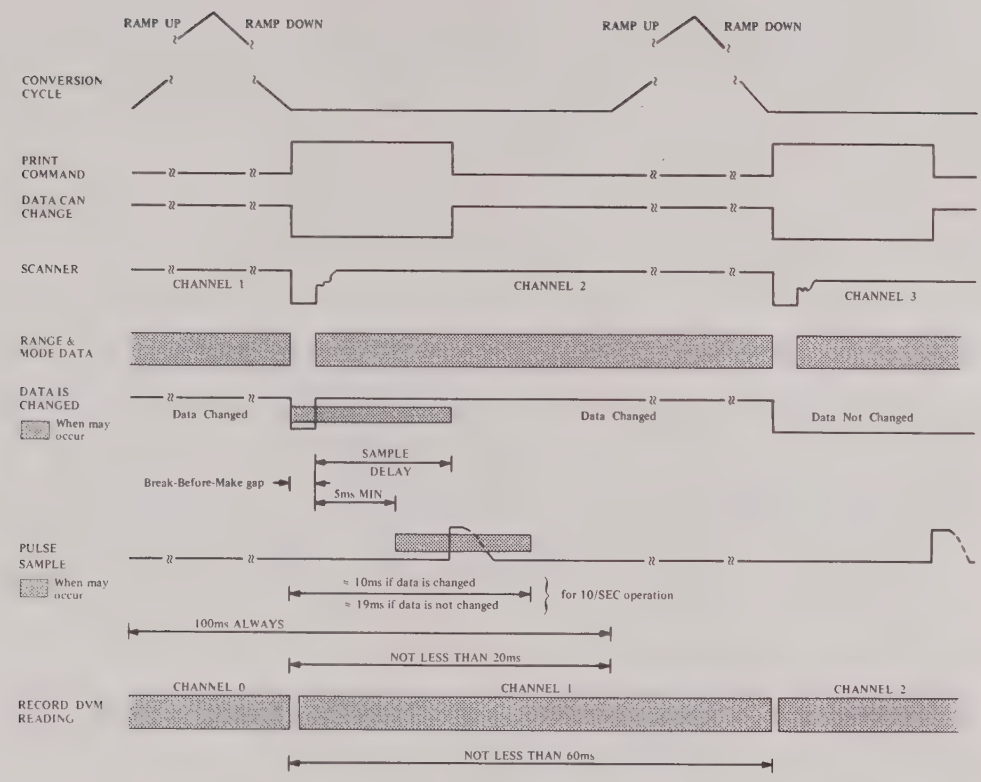



Fig. 5.2 Timing

# SECTION 6 Principles of Operation

## DUAL RAMP

The basic measuring circuit used in these instruments is a bipolar analogue to digital converter operating on the dual ramp principle.

In this technique the unknown input is caused to charge a capacitor for a fixed time. Then, with the unknown removed, a reference voltage is used to discharge the capacitor. The time taken to discharge the capacitor is a measure of the unknown. To ensure that the charge and discharge are linear an integrator is used.

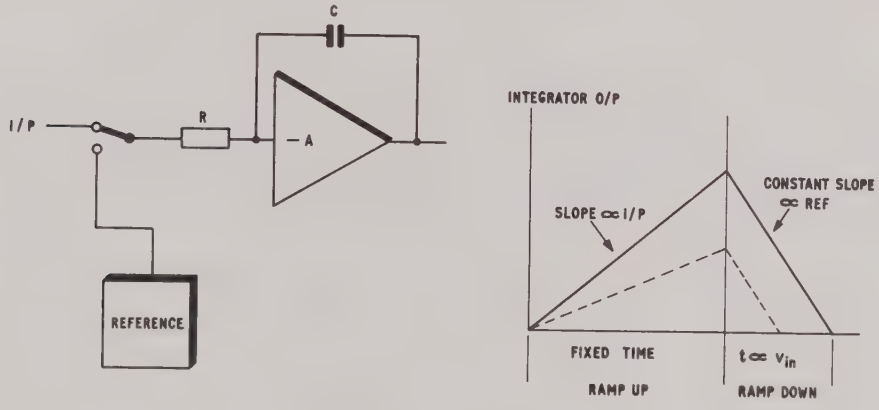



Fig.6.1 Basic Principle

When the integrator is connected to the input its output 'ramps up' at a rate which is directly proportional to the value of the input. After a fixed time the switch changes over and connects the reference in place of the input. It is arranged that the reference voltage is of opposite polarity to that of the input, so that the integrator output now 'ramps down' at a fixed rate which is determined by the value of the reference. The time taken to 'ramp down' is a direct measure of the unknown. The ramp up time can be defined and the ramp down time measured by the arrangement shown below.

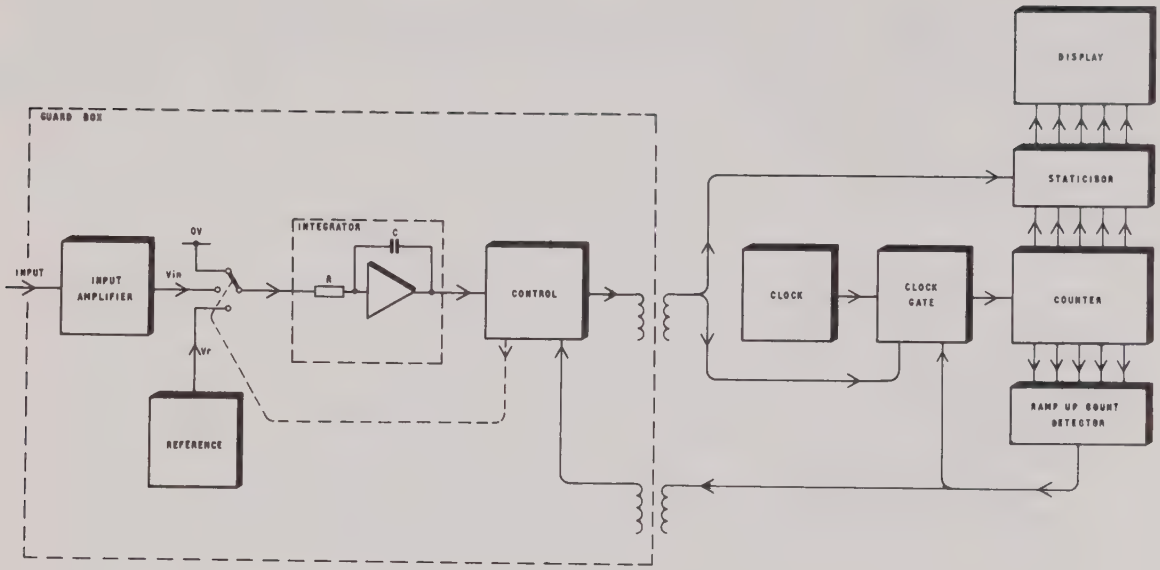



Fig.6.2 Basic Dual Ramp Block Diagram

A measurement cycle is started by the control switching the integrator to the input. At the same time the counter is set to zero and the gate opened. Pulses from the clock then accumulate in the counter while the integrator output rises as a ramp. If the counter has a "full house" of 19999, then the 20000th pulse will return it to zero. It is arranged that when the 20000th pulse is entered, the output pulse generated as the counter resets, causes the control to disconnect the integrator from the input. Ramp up is thus terminated after a period dependent upon the clock frequency and the counter "full house"; a 500kHz clock giving a nominal ramp up time of 40ms.

At the end of ramp up, a voltage ($V_1$) will have been stored on the integrator capacitor. This voltage is

$$V_1 = \frac{VinT_1}{CR} \quad volts \qquad (1)$$

where:- $Vin$ = input voltage

$T_1$ = ramp up time

$C$ and $R$ are the integrator components

The reference (of opposite polarity to the input) is now connected to the integrator which begins ramp down towards zero at a rate proportional to the reference. Meanwhile, clock pulses are still being applied to the counter, which started from zero again as ramp down commenced.

When the ramp reaches zero the gate closes and the control causes the reference to be disconnected from the integrator. Hence ramp down is terminated.

The number of pulses in the counter is directly related to the time taken for ramp down and, because the reference voltage is constant, it is also proportional to $V_1$ which was stored at the end of ramp up.

If, during ramp down, the integrator output at time $t$ is $V_2$ and the reference voltage is $Vr$, then:

$$V_2 = V_1 - \frac{Vr\,t}{CR} \text{ volts} \qquad (2)$$

and after $T_2$ (ramp down time) when $V_2 = 0$ then:

$$V_1 = \frac{Vr\,T_2}{CR} \text{ volts}$$

Hence, from (1) and (2)

$$\frac{VinT_1}{CR} = \frac{VrT_2}{CR}$$

$$\therefore Vin = Vr\,\frac{T_2}{T_1} \text{ volts}$$

Now the number ($N$) of clock pulses accumulated in the counter for a clock frequency of $f$Hz is:-

$$N = T\,f \text{ pulses}$$

Thus $$T = \frac{N}{f} \text{ seconds}$$

$$\therefore Vin = Vr\,\frac{N_2}{f} \cdot \frac{f}{N_1}$$

$$Vin = Vr\,\frac{N_2}{N_1}$$

But $Vr$ and $N_1$ are constant, therefore

$$Vin \propto N_2$$

and is independent of clock frequency.

Thus the number of pulses accumulated by the counter during ramp down is directly proportional to the voltage being measured.

The *MASTER SERIES* of instruments operate basically as described but with certain refinements which significantly improve both accuracy and series mode rejection.

1) In the A200 and A203 only, a digital servo system continuously monitors the 50Hz mains frequency and, by modifying the clock frequency, ensures that ramp up lasts for exactly two mains periods.

2) A 4$\mu$s delay is introduced between the end of the ramp up period and the beginning of ramp down. This allows time for the correct polarity reference to be selected and prevents the possibility of inaccuracies due to switching transients.

3) After completion of ramp down, which can last for up to 40ms, a minimum of 20ms is available before the start of a new measurement for drift correcting the integrator (A200, A203, A220 and A223) and frequency adjusting the clock (A200 and A203 only).

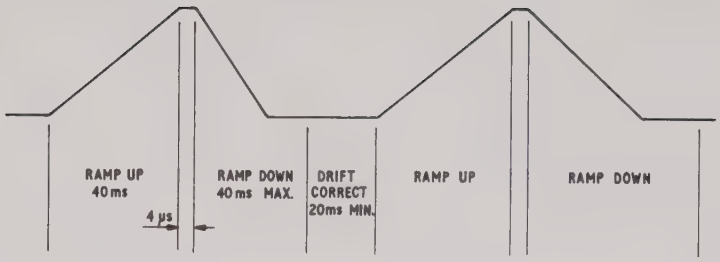



Fig.6.3 Sequence of Operation

## DC MEASUREMENT

For dc measurement the integrator is preceded by an input amplifier using feedback. This arrangement increases the input impedance of the voltmeter and facilitates range switching.

## AC MEASUREMENT

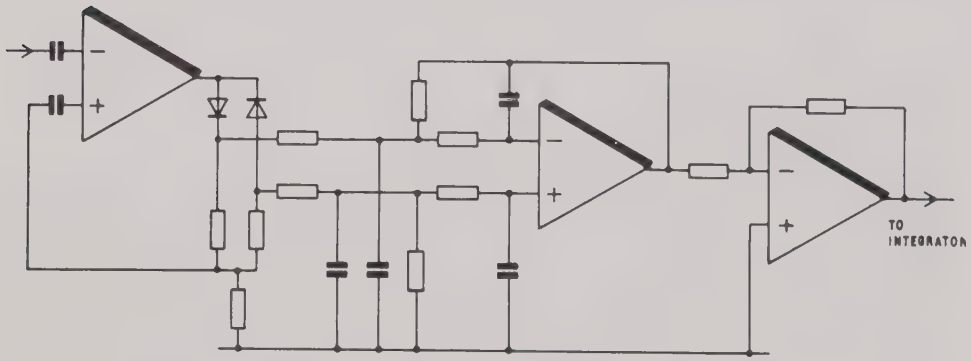



Fig.6.4 AC Measurement

For measurement of ac, the integrator is preceded by an operational rectifier, followed by a filter and an amplifier to obtain a dc signal referred to a common 0V. This dc signal is proportional to the mean rectified ac signal and is scaled by a factor of 1.11, to represent the rms value of a sine wave input, before being applied to the integrator. Thus, the ac is continuously converted to dc for subsequent application to the integrator. Ranging is effected by an input attenuator.

## RESISTANCE MEASUREMENT

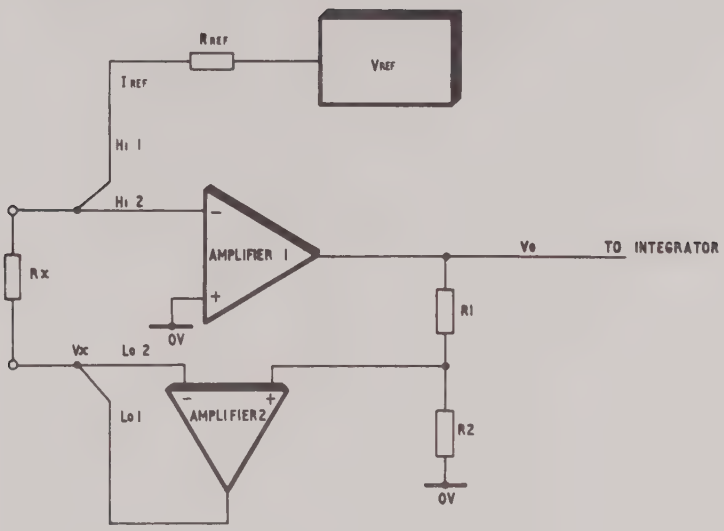



Fig. 6.5 Resistance Measurement

Basically, resistance is measured by measuring the potential developed across the unknown resistor when a known reference current is passed through it.

In the system of resistance measurement used in the A203 and A223, great care has been taken to minimise errors caused by lead resistance. A four terminal technique is used, two terminals apply the reference current whilst two terminals sense the potential difference across the resistor. However, on the standard input lead the connection of the sense leads to the supply leads is effected inside the cable.

$Rx$, the resistance being measured, is made part of the potential divider comprising $R_{REF}$ and $Rx$. This divider is connected between $V_{REF}$ and the output of voltage follower Amplifier 2. The output ($Vx$) of Amplifier 2 is proportional to the output ($Vo$) of Amplifier 1. Amplifier 1 senses the potential at the junction of $R_{REF}$ and $Rx$.

At equilibrium, $Vx$ will be such that the voltage at Hi 2 is the input amplifier error voltage which is very nearly zero.

Then $$\frac{V_{REF}}{R_{REF}} = \frac{Vx}{Rx}$$

Since $Vx$ is proportional to $Vo$ then $Vo \propto Rx$

The lead resistance of Hi 1 cannot cause an error because $R_{REF}$ is always large enough (9.9k, 99k or 9.9M) to 'swamp' the usual level of lead resistance.

The resistance of Lo 1 will not cause an error because the action Amplifier 2 is to define, at the junction of Lo 1, Lo 2 and $Rx$, the same potential as exists at the junction of R1 and R2. Thus the voltage caused by the reference current flowing through the Lo 1 lead resistance appears only across Amplifier 2 and has no effect on the measurement.

The resistance of lead Hi 2 and Lo 2 will have no effect on the measurement because the only current flowing along these leads is amplifier input current, which is so small as to be insignificant.

# SECTION 7 Circuit Description & Servicing Information

## List of Sub-Sections


| Title | Sub-section |
|---|---|
| DC Input (without AC, Ω) | 7.1 |
| DC Input (with AC, Ω) | 7.2 |
| AC Input | 7.3 |
| Ω Input | 7.4 |
| Input Amplifier Connections | 7.5 |
| Input Amplifier (1μV) | 7.6 |
| Input Amplifier (10μV) | 7.7 |
| Floating Relays | 7.8 |
| Range and Mode Logic (with Auto range) | 7.9 |
| Auto Range Logic | 7.10 |
| Range and Mode Logic (without Auto range) | 7.11 |
| Integrator | 7.12 |
| Integrator Control Logic | 7.13 |
| Control Logic | 7.14 |
| Divide by Five and Clock | 7.15 |
| Counter and Display | 7.16 |
| Power Supplies | 7.17 |
| Systems Interface (Fan-out) | 7.204 |

## Introduction

This section, which constitutes the complete circuit description for all the instruments of the series, is arranged in several sub-sections.

The first sub-section (pages 7(i) to 7(xi)) is an overall description of the instruments and also serves as an introduction to the later sub-sections.

Each of the following sub-sections is a detailed description of a particular functional part of the instrument and is based on its circuit diagram, which is found on the final page.

The page numbering system follows that of the circuit diagrams, all information relating to a circuit diagram being found on pages with the same number prefix as the diagram.

Figure 7.1 is a cross-reference chart which also serves as an index to the sub-section. This chart will be found useful if consulted as a peparatory step to circuit investigation. It should be used in conjunction with the Key diagram Fig. 7.6, when it will quickly enable the reader to establish the circuit diagrams which need to be consulted for the model under investigation. It will also show him which pcb's are covered by each diagram.

### OVERALL CIRCUIT DESCRIPTION

This description must be read in conjunction with Fig. 7.6 the Key diagram. It is also assumed that the reader is familiar with the contents of Section 6, "Principles of Operation".

Fig. 7.6 is a block diagram applicable to all instruments in the series. Each block is numbered, the number corresponding to the circuit diagram concerned. For instance see block "14 CONTROL LOGIC". The circuit for this block is No. 14 and all relevant information on this block will be found on pages 7.14.1 to 7.14.6. Reference to Fig. 7.1 the "Cross-reference Chart" shows that this diagram applies to all models and contains major parts of pcb's 9, 25 and 36.

If Fig. 7.6 is studied after reading Section 6 it will be found to be mainly self-explanatory. For clarification the following points are examined in greater detail.

### THE INTEGRATOR (CIRCUIT DIAGRAM No. 12)

This is the heart of the instrument and its theory is covered in detail in Section 6. The input to this block is a dc voltage proportional to the dvm input (whether dc, ac or ohms) and scaled to 6.4V = 19999 clock pulses, (1 clock pulse = 320$\mu$V approx.).

The output of this block is polarity (dvm input – or +) during ramp up and "end of ramp down" signifying that the ramp down has reached zero.

### THE FLOATING BOX

Input selection and scaling, the Integrator and its control are all contained in an electrically isolated guard box. All supplies into this box are via magnetic coupling, either by relays or transformers. Selection is by relays, the coils being located in the earthy section and the contacts in the floating box. Signals to and from the integrator are by pulse transformer (toroids).

### CONTROL LOGIC (CIRCUIT DIAGRAM No. 14)

This circuit provides the timing for the instrument. It starts the ramp-up and detects the polarity from the Integrator; then, after the required time, ends the ramp-up and starts the ramp-down. It then detects the end of ramp-down and commands the display to show the polarity and the count. These are the "Statistise" commands.

## MODEL VARIATIONS

This manual applies to seven models of dvm and two display systems. All models consist of the same Mainframe and the following pcb's:- 3, 4, 5, 6, 9, 11, 12, 22, 23, 25, 26 and 36 together with either 7 or 46 and 47.

The various models are assembled by fitting alternative additional pcb's and the applicable front panel. Table 7.1 shows the appropriate pcb's which are added to the above Basic Assembly to form the various models.

TABLE 7.1

| | | Model | | Model |
|---|---|---|---|---|
| Basic Assembly | + pcb 2 (A200), pcb 8 (A200), pcb 10 (A200), pcb 31 | = A200 | −pcb 31<br>+ pcb 14, pcb 15, pcb 16 | = A203 |
| | | | pcb 31<br>+ pcb 41, pcb 15, pcb 16 | = A205 |
| | + pcb 2 (A220), pcb 8 (A220), pcb 10 (A220), pcb 31 | = A220 | −pcb 10 (A220)<br>+pcb 10 (A200) | = A227 |
| | | | −pcb 31<br>+ pcb 14, pcb 15, pcb 16 | = A223 |
| | | | −pcb 31<br>+ pcb 41, pcb 15, pcb 16 | = A225 |

It should be noted that there are two versions of pcb's 2, 8 and 10 and care should be exercised when ordering or fitting replacements for these boards that the correct type No. is used.

The System Interface (A204) consisting of pcb's 27 and 28 can be fitted to all models.

## CIRCUIT DIAGRAMS

Sections 7 to 9 were initially prepared before the introduction of models A205, A225 and A227 and before the introduction of the seven bar display. For this reason some of the references and annotations may be incomplete. If any doubt exists a check should be made with the Cross Reference Chart (Fig. 7.1). For example, circuit diagram No. 9 is labelled "(A200 and A203)" whereas Fig. 7.1 shows that it also applies to the A205 and A227.

| CIRCUIT | | PRINTED CIRCUIT BOARDS | | APPLICABLE TO A200 | A203 | A205 | A220 | A223 | A225 | A227 |
|---|---|---|---|---|---|---|---|---|---|---|
| DC Input, (No AC, Ω) | 1 | 2 | A200 Input Amplifier | | | | | | | |
| DC Input, (AC, Ω) | 2 | 2 | A220 Input Amplifier | | | | | | | |
| AC Input (Mean Sensing) | 3a | 3 | Integrator and Reference | | | | | | | |
| AC Input (True RMS) | 3b | 4 | Toroid Receiver and Logic | | | | | | | |
| Ohms Input | 4 | 5 | Floating PSU and FET Drivers | | | | | | | |
| Input Amplifier Connections | 5 | 6 | Floating Mother Board | | | | | | | |
| Input Amplifier (1μV) | 6 | 7 | Display Board (Nixie) | | | | | | | |
| Input Amplifier (10μV) | 7 | 8 | A200 Control Discrete Circuits | | | | | | | |
| Floating Section Relays | 8 | 8 | A220 Control Discrete Circuits | | | | | | | |
| Range and Mode Logic | 9 | 9 | Control Logic (Earthy) | | | | | | | |
| Auto Range Logic | 10 | 10 | A200 Mode and Range Logic | | | | | | | |
| Range and Mode Logic | 11 | 10 | A220 Mode and Range Logic | | | | | | | |
| Integrator | 12 | 11 | Counter Logic | | | | | | | |
| Integrator Control Logic | 13 | 12 | Earthy Power Supply | | | | | | | |
| Control Logic | 14 | 14 | AC Converter | | | | | | | |
| Divide by 5 and Clock | 15 | 15 | AC Auxilliary Board | | | | | | | |
| Counter and Display (Nixie) | 16a | 16 | Ohms and AC Filter Board | | | | | | | |
| Counter and Display (7 Seg.) | 16b | 22 | Earthy Power Supply | | | | | | | |
| Power Supplies | 17 | 23 | Range and Mode Switches | | | | | | | |
| A204 Systems Interface (Sh.1.) | — | 25 | Filter, Remote and Rate Switches | | | | | | | |
| A204 Systems Interface (Sh.2.) | — | 26 | Range and Filter Board | | | | | | | |
| | | 27 | Fan-out A204 | | | | | | | |
| | | 28 | Fan-out A204 | | | | | | | |
| | | 31 | Link Board | | | | | | | |
| | | 36 | Toroid Driver Board | | | | | | | |
| | | 41 | True RMS Board | | | | | | | |
| | | 46 | Display Board (7 Seg.) | | | | | | | |
| | | 47 | Display Driver (7 Seg.) | | | | | | | |

| APPLICABLE TO | A200 | A203 | A205 | A220 | A223 | A225 | A227 |
|---|---|---|---|---|---|---|---|
| 2 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |
| 5 | | | | | | | |
| 6 | | | | | | | |
| 7 | NIXIE | | | | | | |
| 8 | | | | | | | |
| 8 | | | | | | | |
| 9 | | | | | | | |
| 10 | | | | | | | |
| 10 | | | | | | | |
| 11 | | | | | | | |
| 12 | | | | | | | |
| 14 | | | | | | | |
| 15 | | | | | | | |
| 16 | | | | | | | |
| 22 | | | | | | | |
| 23 | | | | | | | |
| 25 | | | | | | | |
| 26 | | | | | | | |
| 27 | OPTIONAL | | | | | | |
| 28 | | | | | | | |
| 31 | | | | | | | |
| 36 | | | | | | | |
| 41 | | | | | | | |
| 46 | 7 SEG. | | | | | | |
| 47 | | | | | | | |

**A200 Circuit Diagram/Printed Circuit Board Cross Reference Chart**

This chart lists the pcb's horizontally and the circuit diagrams vertically. If the circuit diagram contains a significant amount of detail, the correlation between them is down by an intersecting cross. If the correlation is of a minor nature it is shown by a stroke.

The applicability tables to the right and beneath the main chart indicate the dvm models affected. The right hand chart shows the allocation of circuit diagrams and the lower the allocation of pcb's for each model.

**Fig. 7.1 Cross-reference Chart**

## KEY DIAGRAM

The Key Diagram (Fig. 7.6) appears at the end of this sub section.

This diagram presents a visual Key as to how the **Functional Circuit Diagrams**, numbered **1 to 17**, together with **Fan Out Sheets 1 and 2** are linked together.

Notation of signals and commands on the Key Diagram appear on the Circuit Diagrams as flagged indications of inputs and outputs.

The numbers in the blocks refer to the functional drawings comprising **Section 7**.

In the general description which follows references to models A200 and A203 should also include the A205 and references to A220 and A223 should include the A225. See also under the heading "**Circuit Diagrams**".

The **Input Mode, DC (1 or 2), AC (3) and Ω(4)** is selected by commands from either **Range and Mode Logic (9)**, A200 and A203 or **Range and Mode Logic (11)**,A220 and A223. Commands are initiated either by operating the front panel controls of range and mode, or by remote commands in logic levels (TTL Compatible) to the **A204 Fan Out** (see Section 6, Remote Commands).

Commands are transferred to the Floating Section via Relay Coils A, B, D and E (DC Ranges and Filter; all instruments) and F, H, J and K (AC Ranges and Filter; Ω Mode; A203 and A223 only). This is shown in **Floating Section Relays (8)**.

In DC Mode, the amplifier shown in **Input Amplifier Connection (5)** is range scaled so that the same FSD output voltage is applied to the **Integrator (12)**.

The **Input Amplifier (6 or 7)** has a high open loop gain necessary for accurate scaling and, because the input signal forms part of the amplifier feed back loop, a very high input resistance, required for accurate measurement is achieved. See 'High Accuracy Digital Voltage Measurement', DVM Monograph No.8, for further discussion.

In AC Mode, the applied ac is first attenuated, then converted to dc and finally filtered and applied as a 1V (FSD) signal to the Input Amplifier; refer to **Input Amplifier Connection (5)**. which is set to the 1V DC Range.

For Ω Mode, refer to Fig.6.5 and **Ω Input (4)**. The unknown resistance is measured by passing a known reference current through it and applying the voltage developed to the **Input Amplifier (6 or 7)**, scaled for resistance as in **Input Amplifier Connection (5)**. In Fig.6.5, Amplifier 1 is the Input Amplifier and Amplifier 2 is voltage follower shown in **Ω Input (4)** which ensures that the voltage in Lo 1 produced by the reference current is not added to the voltage across the unknown resistor.

The timing of events is derived from the mains frequency in the **Power Supply (17)**. The **Divide by 5 and Clock (15)** sets the 10Hz reading rate (12Hz from 60Hz Mains) and provides the 500kHz clock frequency (600kHz from 60Hz mains). In the A200 and A203, the clock frequency is adjusted during the drift correct period so that Ramp up lasts for exactly two mains periods.

**The Integrator (12)** compares the scaled amplifier output, switched during ramp up, with either the positive reference (for negative integrator input positive dvm inputs) or the negative reference (positive integrator input, negative dvm inputs), switched during ramp down. The ramp up time is 19999 clock pulses (40ms or 2 mains periods), ramp up being commanded at the start of the measuring cycle from the Ramp Up Bistable in **Control Logic (14)**. At this time the Counter in **Counter and Display (16)** is set to zero, the Counter Clock Gate opens passing clock pulses to the Counter. On the 19999th pulse the integrator capacitor, C14, in Integrator (12) will have charged to a value proportional to input voltage (approximately 11.4V for a "full house" dvm input). The 20000th pulse returns the counter to zero, ramp up ends and the scaled amplifier output is disconnected from the integrator. Polarity decision of the dvm input is made and the correct reference polarity selected. 4μs after the end of ramp up, ramp down is commanded from the **Control Logic (14)**, and the correct reference voltage switched to the Integrator Input.

The Counter Clock Gate, however, is not opened until 12$\mu$s after the start of ramp down, when the ramp down slope is linear. To correct for this, a small offset is applied to the Comparator, in **Integrator (12)**, to allow ramp down to continue beyond zero before end of ramp down is detected. When end of ramp down is detected, it is signalled from the Integrator to **Control Logic (14)** via **Integrator Control Logic (13)**. The Counter Clock Gate is closed, the Ramp Down Bistable commands end of ramp down and commence drift correct to the Integrator. 8$\mu$s later, the number stored in the Counter in **Counter and Display (16)** is clocked to the Display Tubes, i.e. staticised by a clock pulse; "Staticise Data" from **Control Logic (14)**.

This value is the digital conversion of the analogue input to the instrument.

For a "full house" input, ramp down will be 40ms (50Hz mains), the 500kHz (600kHz from 60Hz mains) clock pulses producing a count of 19999 in the Counter.

Drift correct is approximately 20ms for a 19999 reading. During drift correct, the offset charge on the integrator capacitor C14, produced by ramp down continuing beyond zero, is feed back to the integrator input via the drift correct capacitor C15. This ensures that the integrator capacitor is fully discharged to zero by the time the next measuring cycle commences.

The **A204 Fan Out** enables both remote operation of the dvm and the transfer of displayed data to a recording system.

**CAUTION : EXTRACTION OF PCB's**

Careless extraction of PCB's could damage the edge connectors. They should always be extracted evenly from the edge connector socket and NOT by pivoting about one corner.

**ACCESS TO PCB's**

1) Release side panel bracket screws located left and right of the rear panel.

2) Remove the side panels by extracting from the back of the instrument.

3) Top and Bottom panels may now be removed by sliding back to clear the rear panel.

For calibration, the top panel only need be removed, and then only sufficiently for access to the appropriate adjustment.

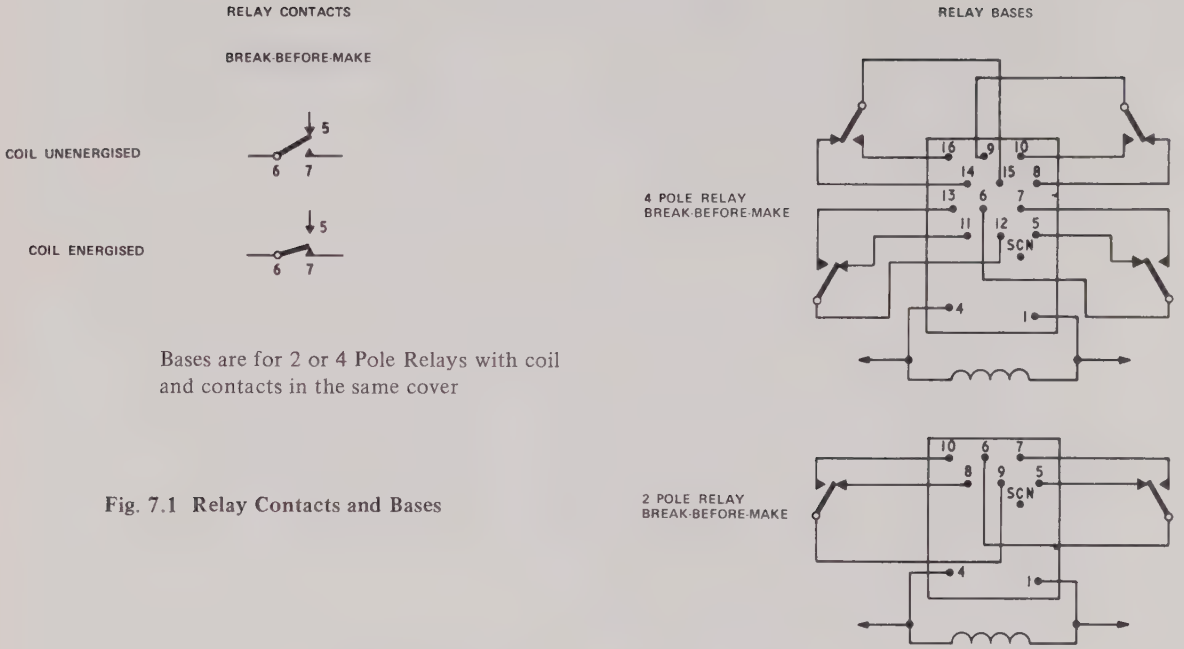
**EXTENSION BOARD KIT AND 1C PIN CLIP**

The use of EX3188 Extension Board Kit is recommended for efficient pcb access.

| **Extension Board Nos.** | | **DVM Board Nos.** |
|---|---|---|
| A2009032, 32 Way | for | Boards 8 and 11 |
| A2009033, 44 Way | for | Boards 2,3,4,5,7,14 and 16. |
| A2009037, 24 Way | for | Board 10 |
| A2009038, 16 Way | for | Board 9 |
| A2009039, 24 Way | for | Fan Out A204. |

The use of a **Dual In Line IC Clip, 16 Pin**, such as that supplied by Electronic Component Supplies Limited, Thames Avenue, Windsor, Bucks, is recommended for checking IC pin voltages.

## RELAY CONTACTS AND BASES




Bases are for 2 or 4 Pole Relays with coil and contacts in the same cover

**Fig. 7.1 Relay Contacts and Bases**

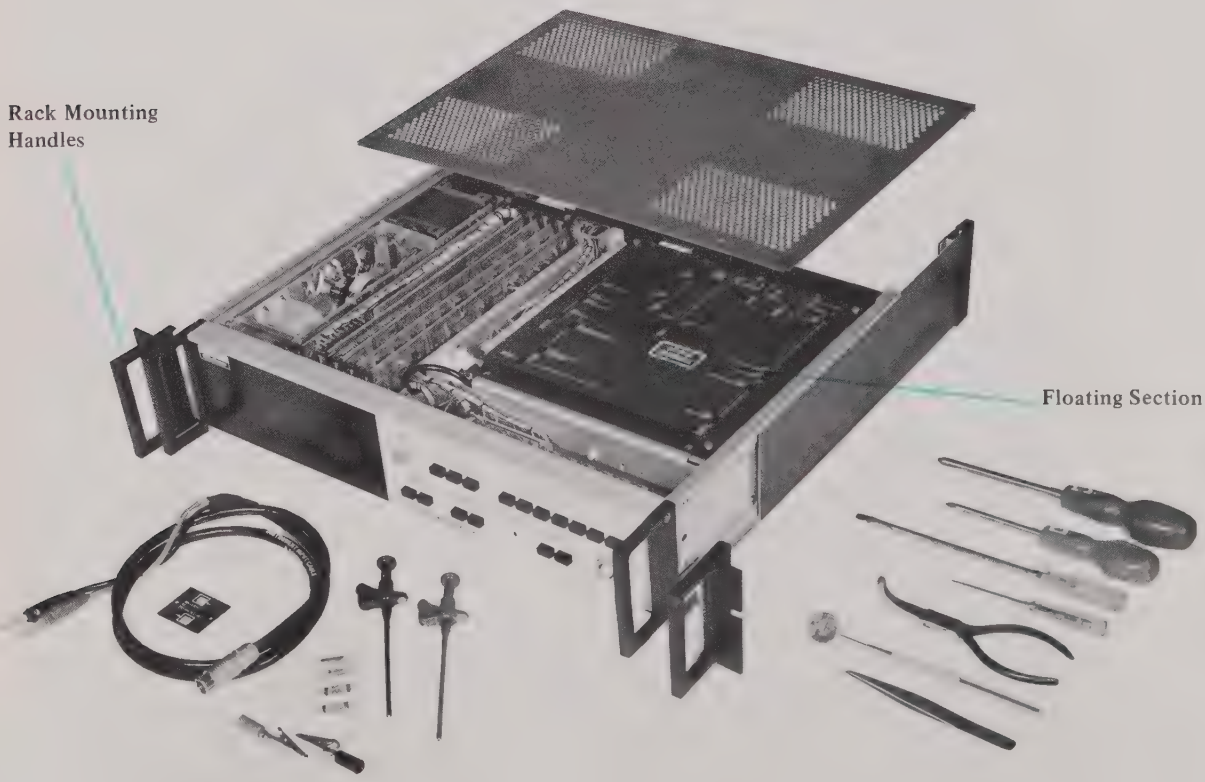



**Fig. 7.2 Removal of Top and Side Panels**

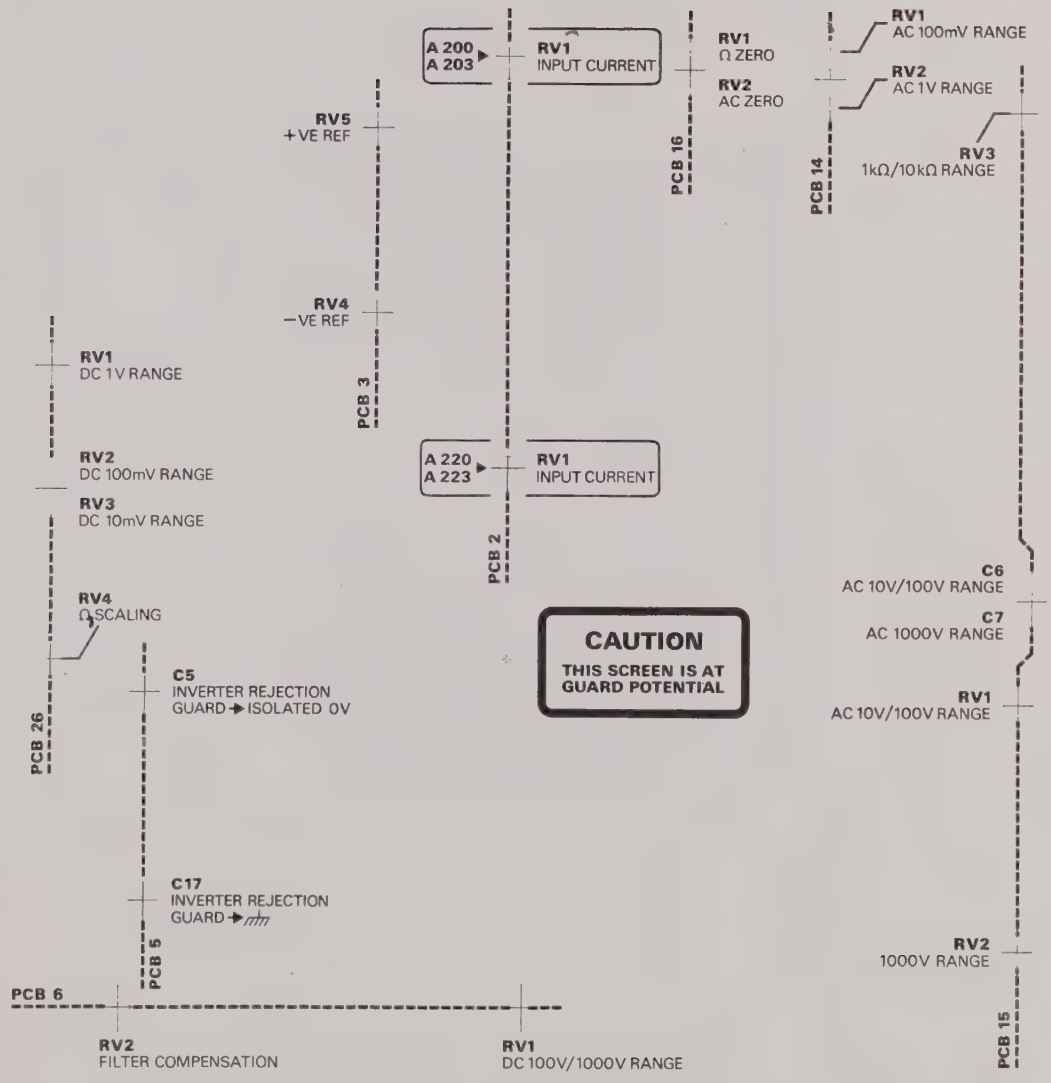



Fig. 7.3 Floating Section Cover

Remove the four corner screws for access to the floating section

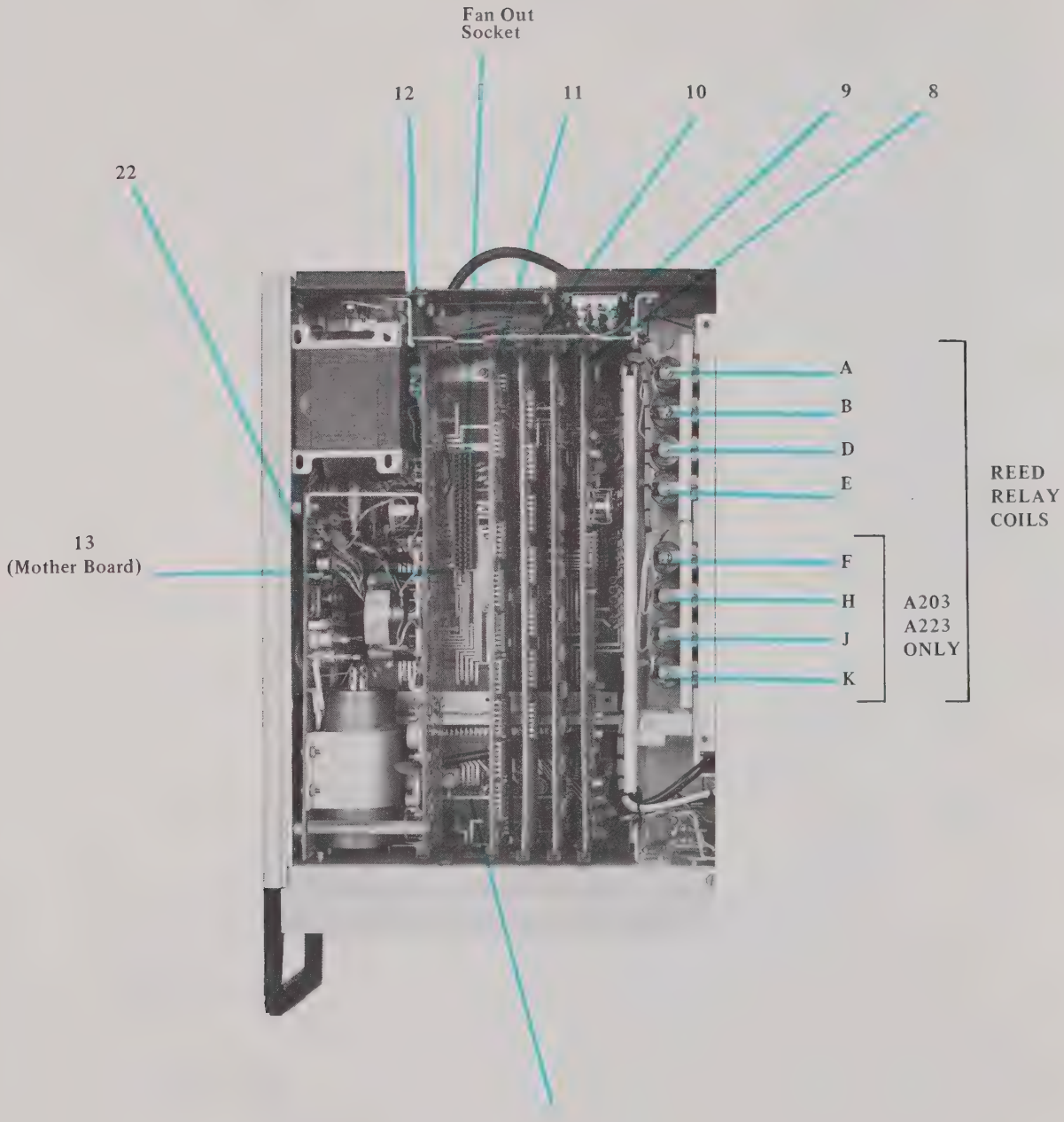
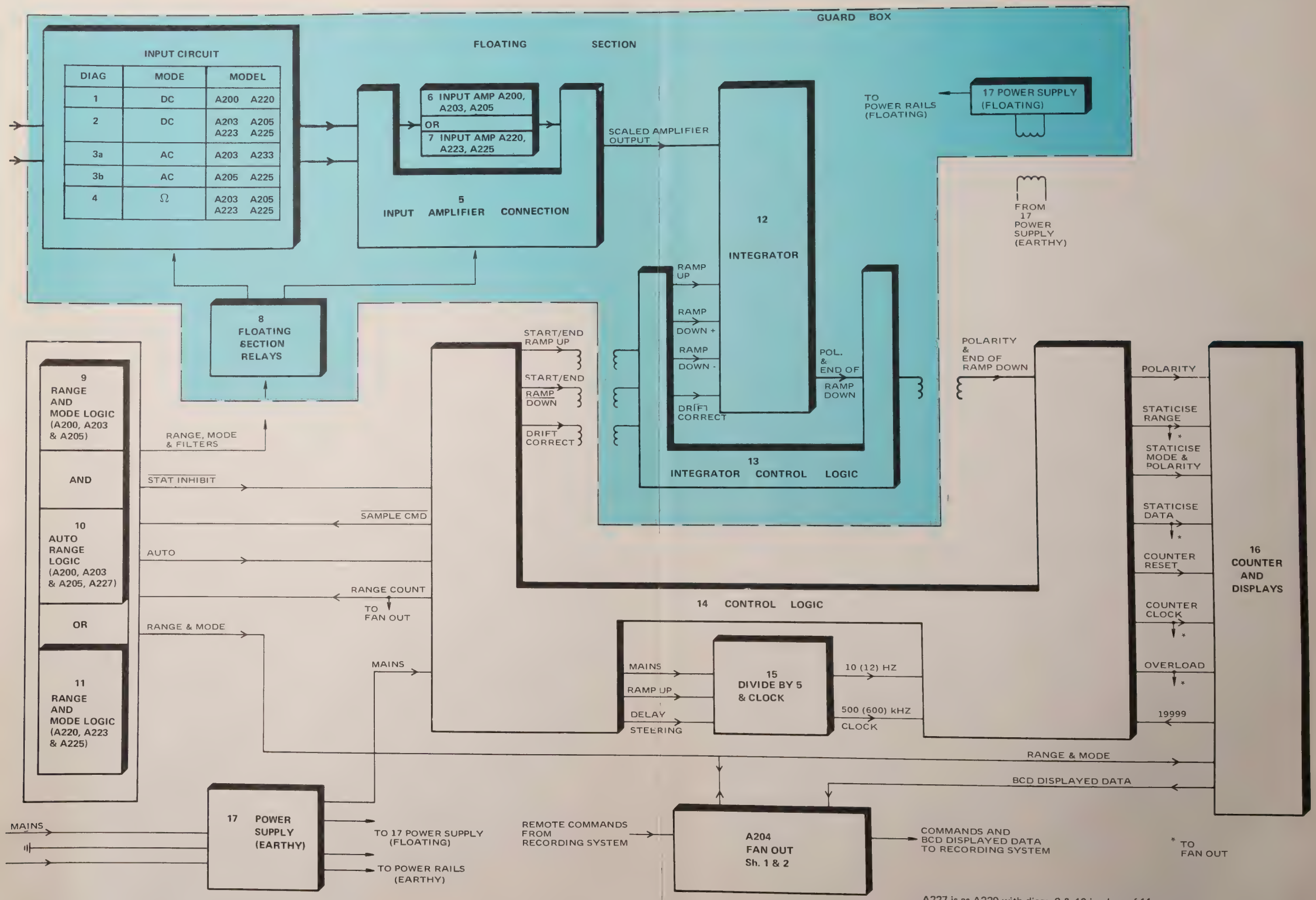





Fig. 7.4 Earthy Section Pcb Location

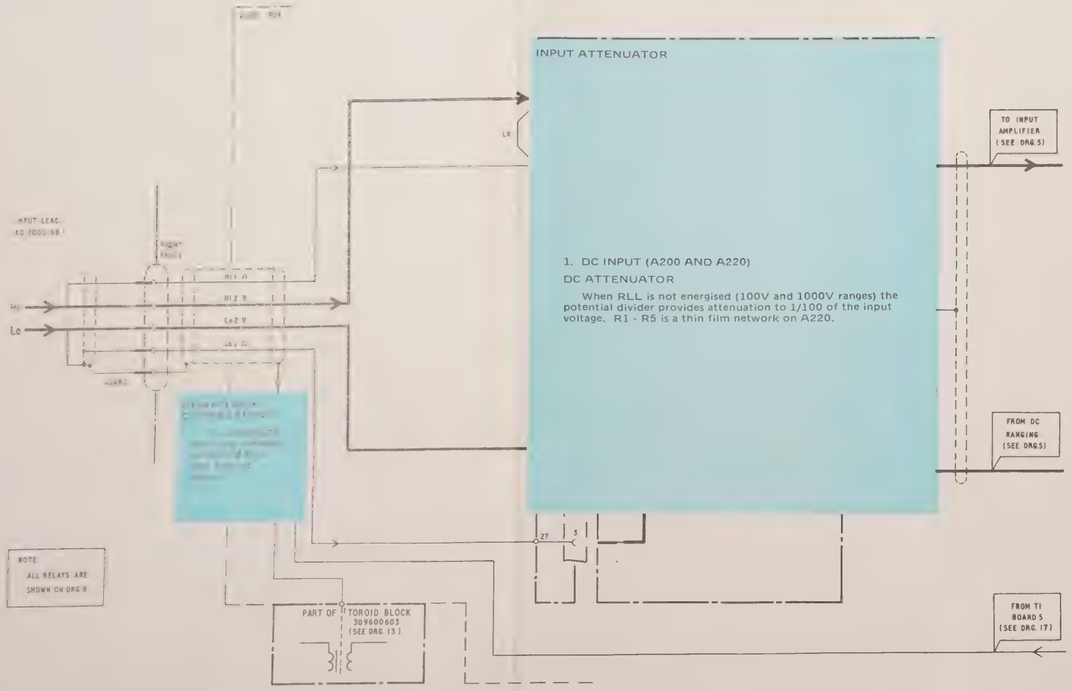
Pcb's 8, 9, 10, 11 and 12 are secured by clips. Pcb 22 is bolted to the left hand frame by 4 screws.




A227 is as A220 with diags. 9 & 10 in place of 11

Fig. 7.6 KEY DIAGRAM

PART OF FLOATING SECTION


INPUT ATTENUATOR
1. DC INPUT (A200 AND A220)
DC ATTENUATOR
When RLL is not energised (100V and 1000V ranges) the potential divider provides attenuation to 1/100 of the input voltage. R1 - R5 is a thin film network on A220.
TO INPUT AMPLIFIER (SEE DRG.5)
FROM DC RANGING (SEE DRG.5)
FROM TI BOARD 5 (SEE DRG. 7)
PART OF TOROID BLOCK 309600603 (SEE DRG. 13)
Hi
Lo
Hi 2 V
Lo 2 V
NOTE
ALL RELAYS ARE SHOWN ON DRG 8

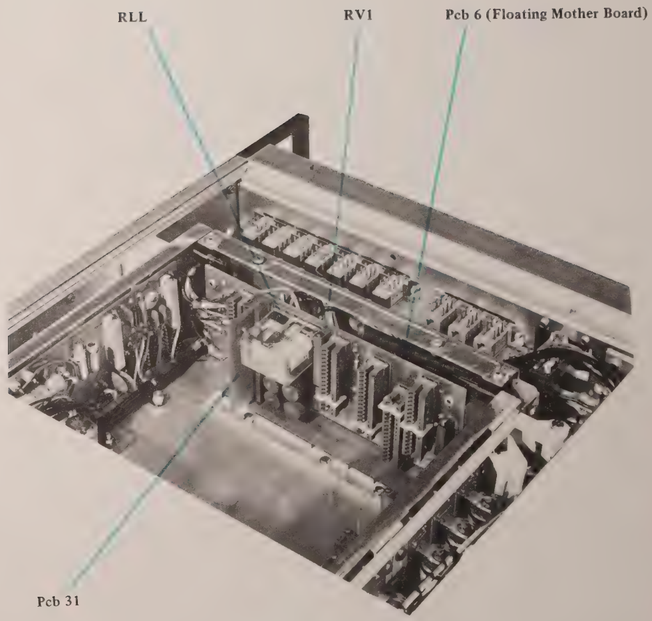



Fig. 7.7 Pcb 6, Pcb 31

DC INPUT
(A200 AND A220)
DESCRIPTION 1

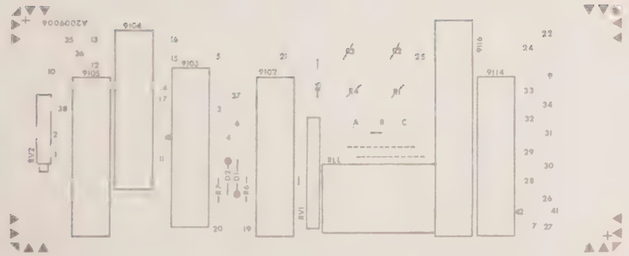


Fig. 7.8 Pcb 6 (Component Side)

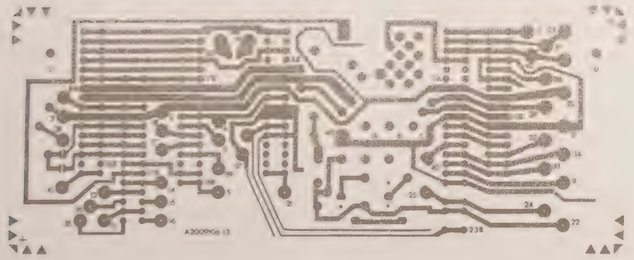
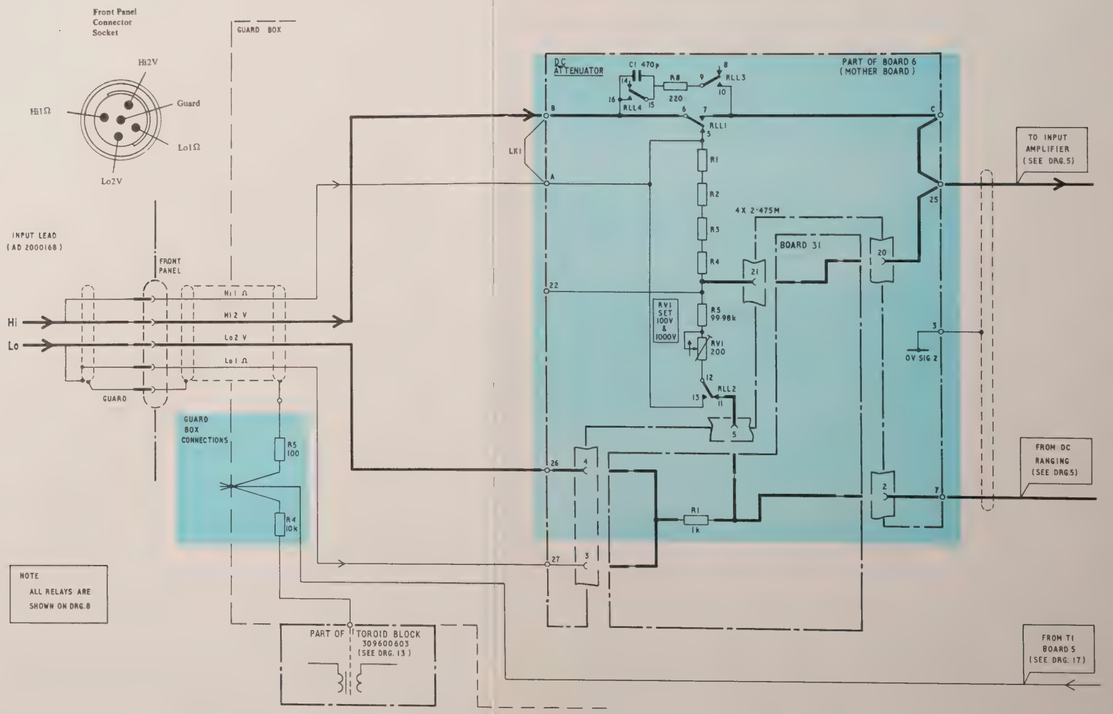


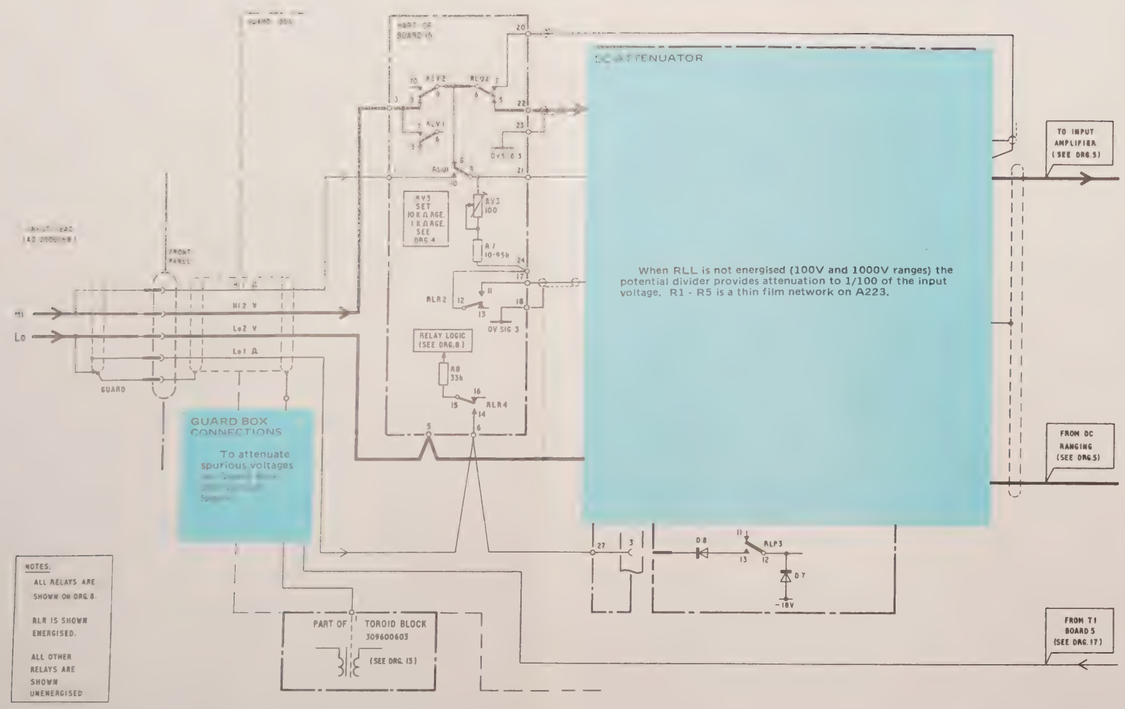
Fig.7.9 Pcb 6 (Copper Side)

Fig. 7.10 Pcb 31

PART OF FLOATING SECTION




DC INPUT CIRCUIT (WITHOUT AC,Ω) 1


PART OF FLOATING SECTION
ATTENUATOR
When RLL is not energised (100V and 1000V ranges) the potential divider provides attenuation to 1/100 of the input voltage. R1 - R5 is a thin film network on A223.
GUARD BOX CONNECTIONS
To attenuate spurious voltages
TO INPUT AMPLIFIER (SEE DRG.5)
FROM DC RANGING (SEE DRG.5)
FROM T1 BOARD 5 (SEE DRG.17)
RELAY LOGIC (SEE DRG.8)
PART OF TOROID BLOCK 30600603 (SEE DRG. 13)
Hi 2 V
Lo 2 V
Lo 1 A
GUARD
NOTES:
ALL RELAYS ARE SHOWN ON DRG 8.
RLR IS SHOWN ENERGISED.
ALL OTHER RELAYS ARE SHOWN UNENERGISED



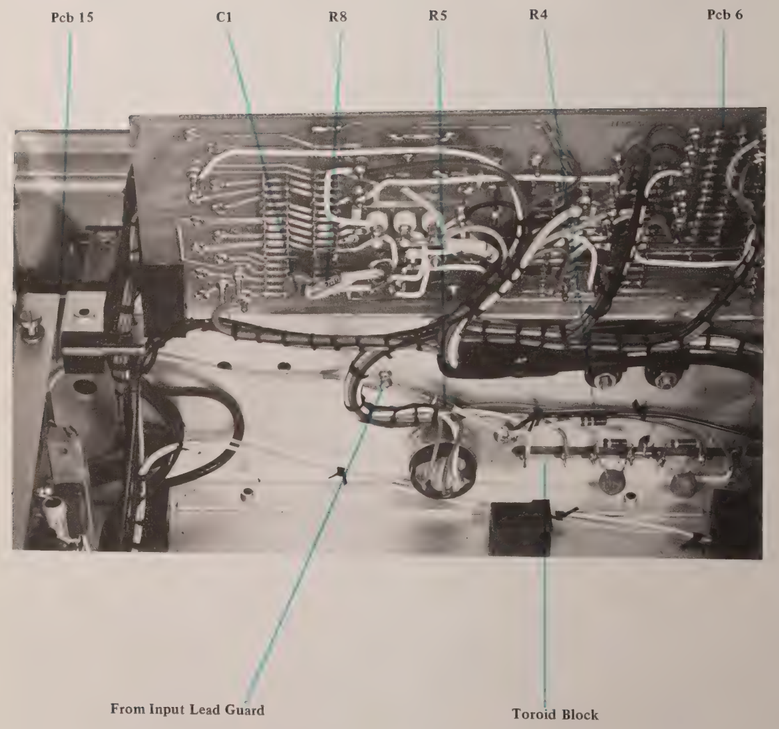
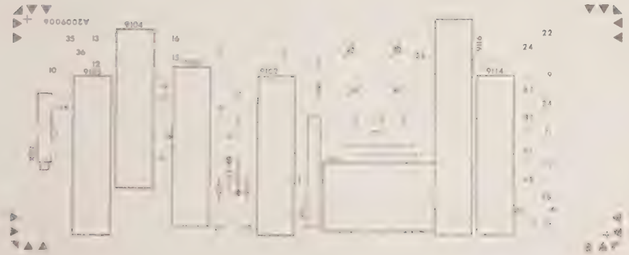



Fig. 7.11 Pcb 6. Copper Side Wiring

DC INPUT
(A203 AND A223)
DESCRIPTION 2



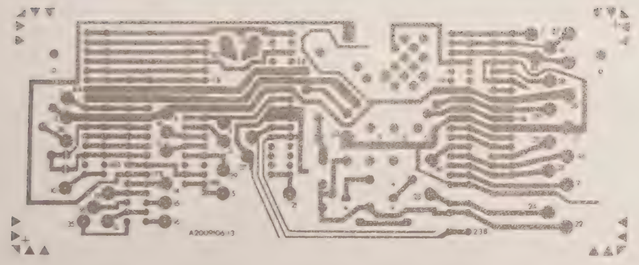
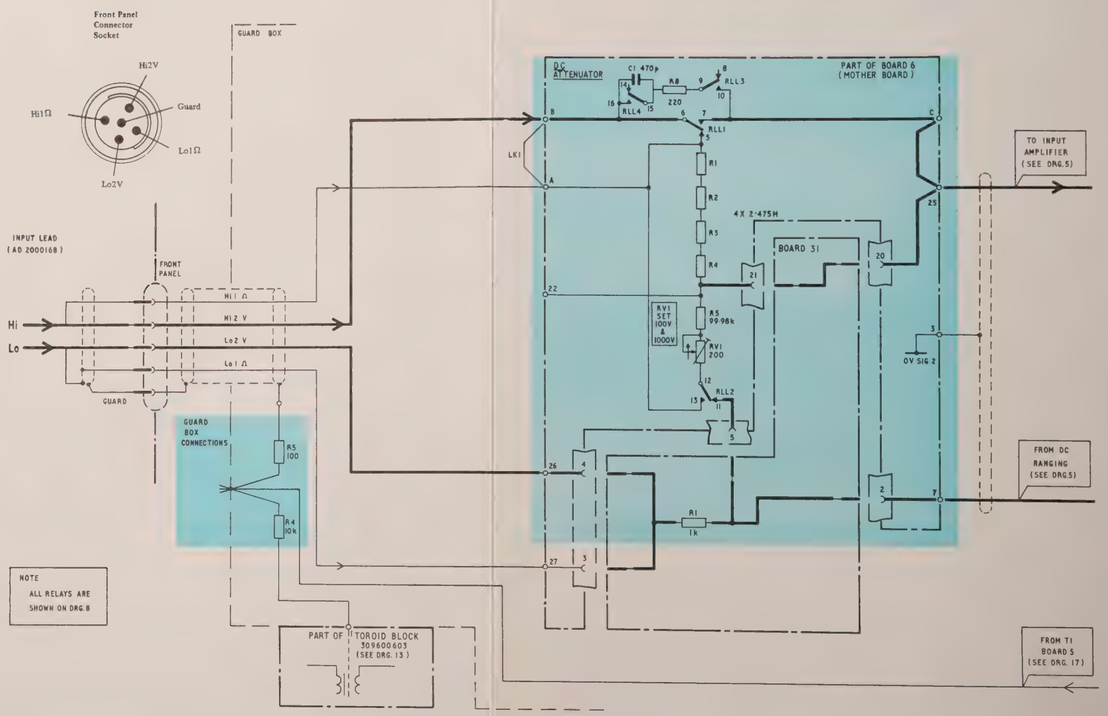


Fig.7.9 Pcb 6 (Copper Side)

Fig. 7.10 Pcb 31

PART OF FLOATING SECTION




DC INPUT CIRCUIT (WITHOUT AC,Ω) 1

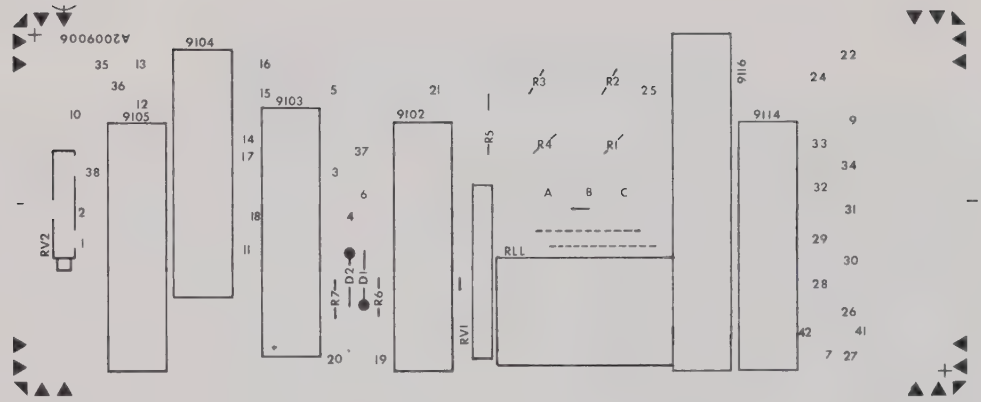



Fig. 7.13 Pcb 6 (Component Side)

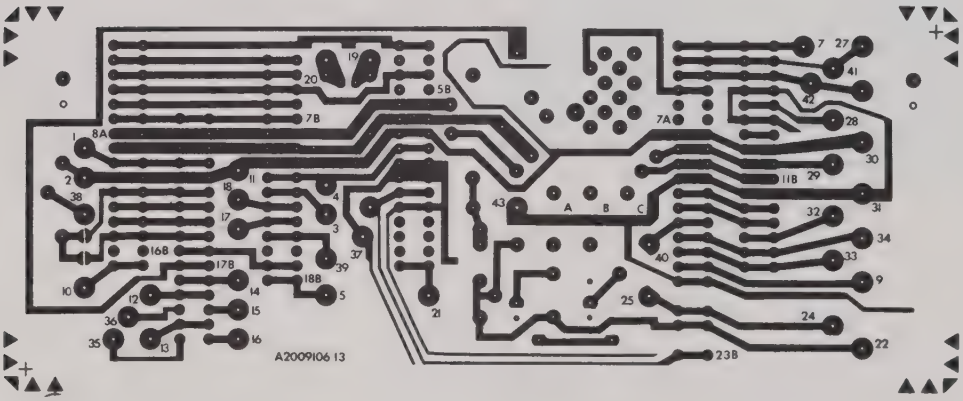
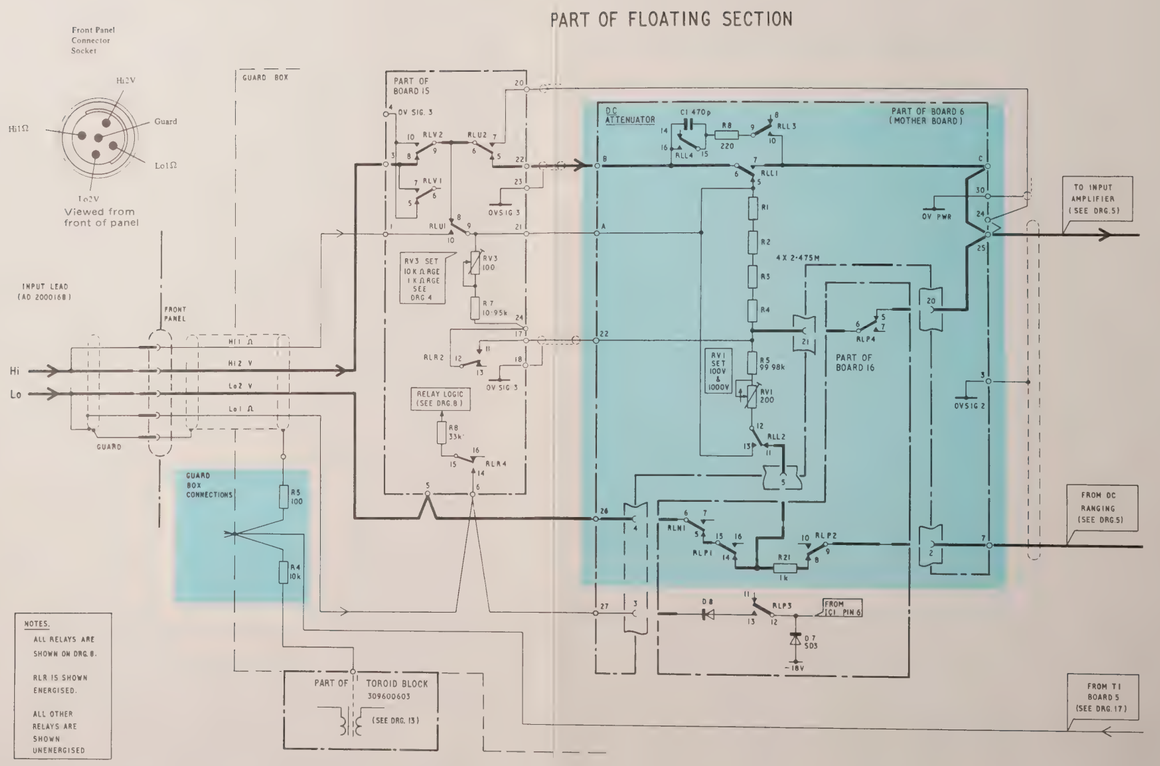


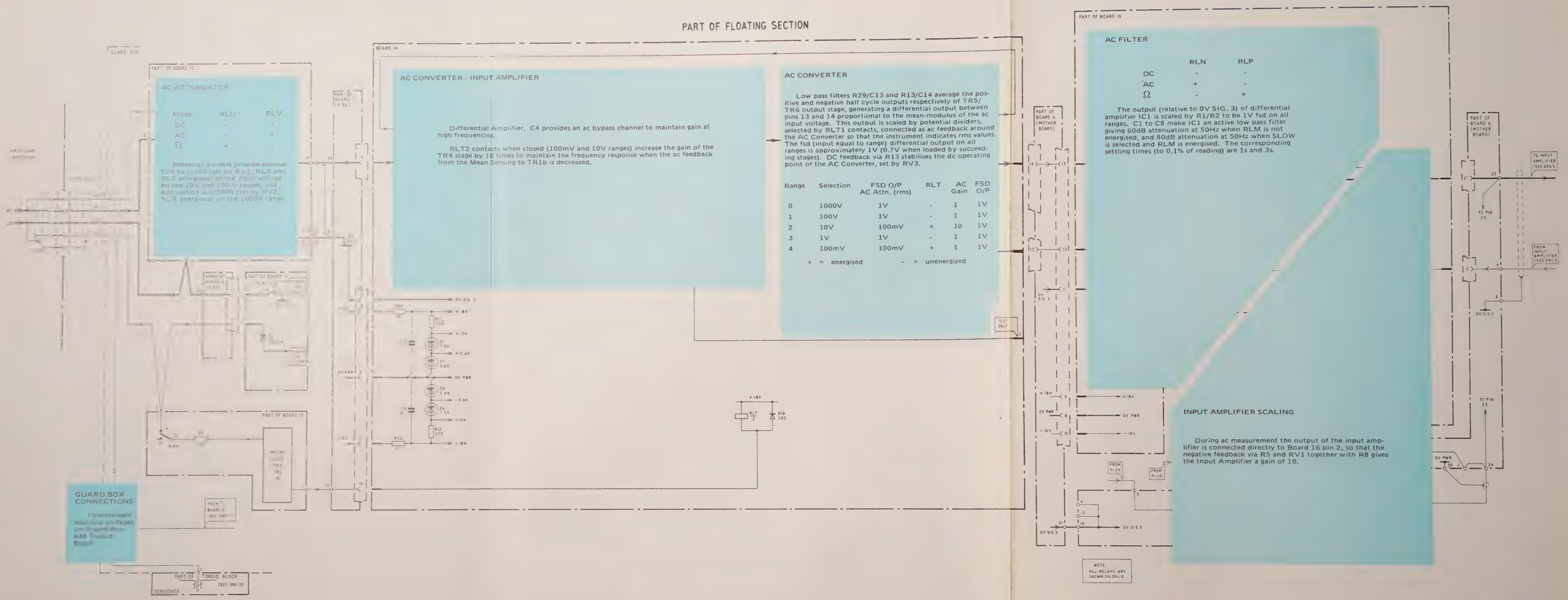

Fig. 7.14 Pcb 6 (Copper Side)

For Pcbs 15 and 16 Components see DRG 3 Figs.7.18 and 7.20.




DC INPUT CIRCUIT (WITH AC, Ω) 2

JR/A200/2


PART OF FLOATING SECTION
GUARD BOX
PART OF BOARD 15
AC ATTENUATOR
Mode RLU RLV
DC - -
AC - +
Ω + -
Potential dividers provide attenuation to 1/100 (set by RV1, RLR and RLS energised) of the input voltage on the 10V and 100 V ranges, and attenuation is 1/1000 (set by RV2, RLR energised) on the 1000V range.
BOARD 14
AC CONVERTER - INPUT AMPLIFIER
Differential Amplifier. C4 provides an ac bypass channel to maintain gain at high frequencies.
RLT2 contacts when closed (100mV and 10V ranges) increase the gain of the TR4 stage by 10 times to maintain the frequency response when the ac feedback from the Mean Sensing to TR1b is decreased.
AC CONVERTER
Low pass filters R29/C13 and R13/C14 average the positive and negative half cycle outputs respectively of TR5/TR6 output stage, generating a differential output between pins 13 and 14 proportional to the mean-modulus of the ac input voltage. This output is scaled by potential dividers, selected by RLT1 contacts, connected as ac feedback around the AC Converter so that the instrument indicates rms values. The fsd (input equal to range) differential output on all ranges is approximately 1V (0.7V when loaded by succeeding stages). DC feedback via R13 stabilises the dc operating point of the AC Converter, set by RV3.
Range Selection FSD O/P AC Attn. (rms) RLT AC Gain FSD O/P
0 1000V 1V - 1 1V
1 100V 1V - 1 1V
2 10V 100mV + 10 1V
3 1V 1V - 1 1V
4 100mV 100mV + 1 1V
+ = energised - = unenergised
PART OF BOARD 16
AC FILTER
RLN RLP
DC - -
AC + -
Ω - +
The output (relative to 0V SIG. 3) of differential amplifier IC1 is scaled by R1/R2 to be 1V fsd on all ranges. C1 to C8 make IC1 an active low pass filter giving 60dB attenuation at 50Hz when RLM is not energised, and 80dB attenuation at 50Hz when SLOW is selected and RLM is energised. The corresponding settling times (to 0.1% of reading) are 1s and 3s.
INPUT AMPLIFIER SCALING
During ac measurement the output of the input amplifier is connected directly to Board 16 pin 2, so that the negative feedback via R5 and RV1 together with R8 gives the Input Amplifier a gain of 10.
GUARD BOX CONNECTIONS
To attenuate stabilised voltages in Guard Box and Toroid Block
PART OF TOROID BLOCK
NOTE ALL RELAYS ARE SHOWN ON Dru B

# AC INPUT (MEAN SENSING, A203 AND A223) DESCRIPTION 3

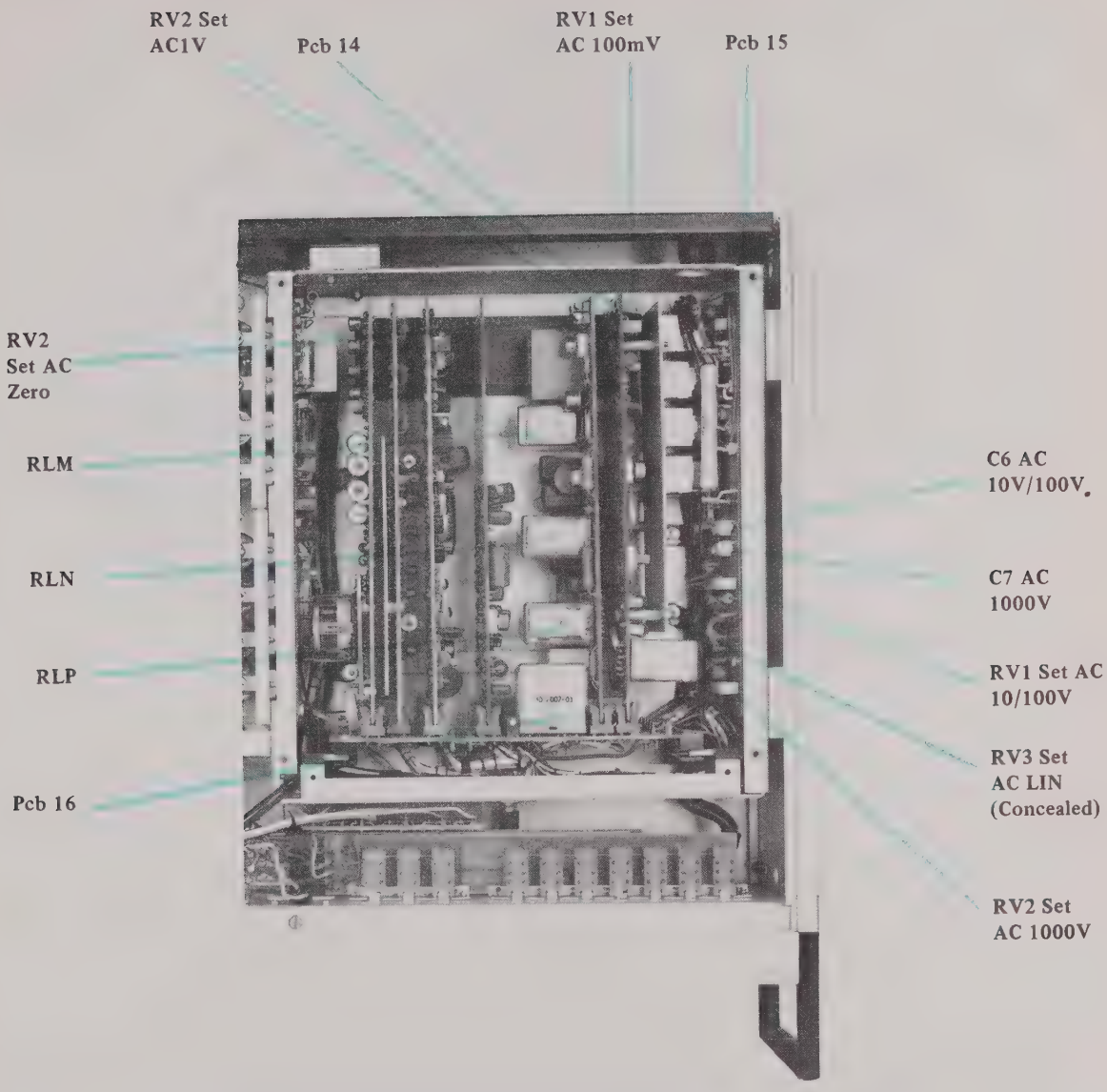



Fig. 7.15 Pcb's 14, 15 , 16 and 6

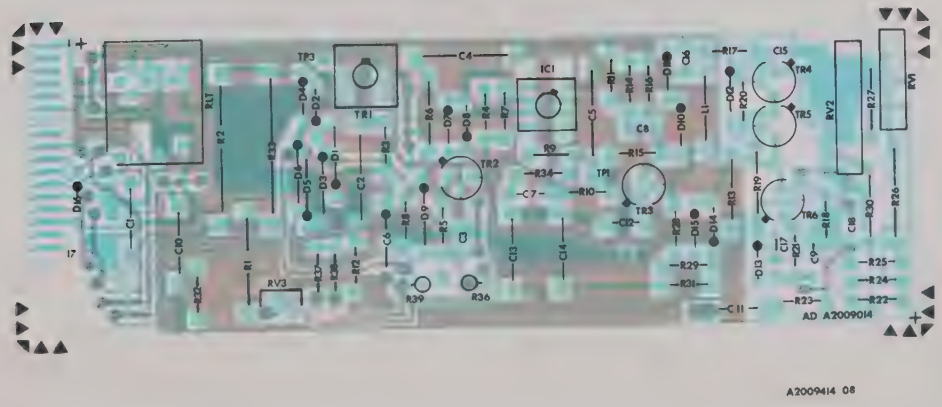



Fig. 7.16 Pcb 14

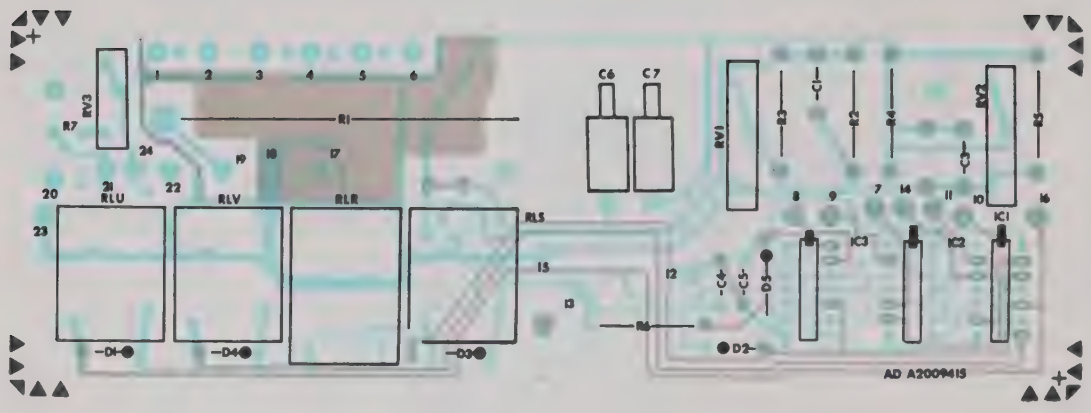



Fig. 7.18 Pcb 15

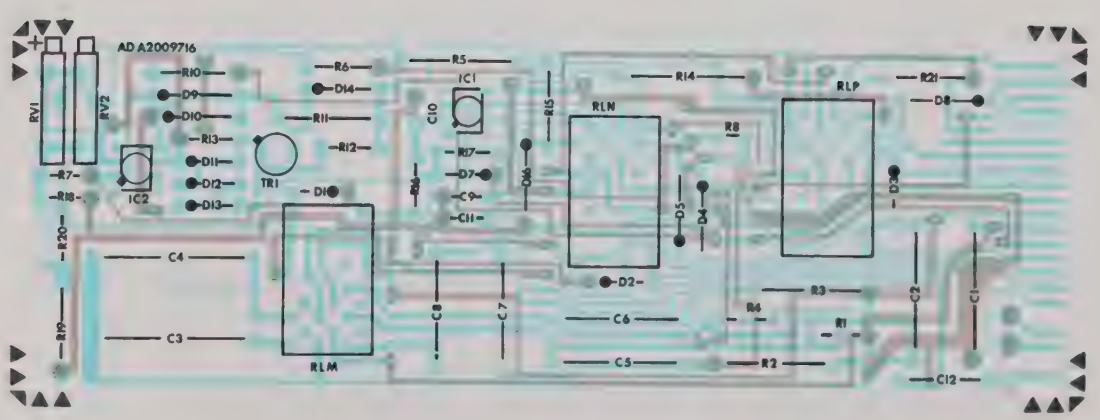



Fig. 7.20 Pcb 16

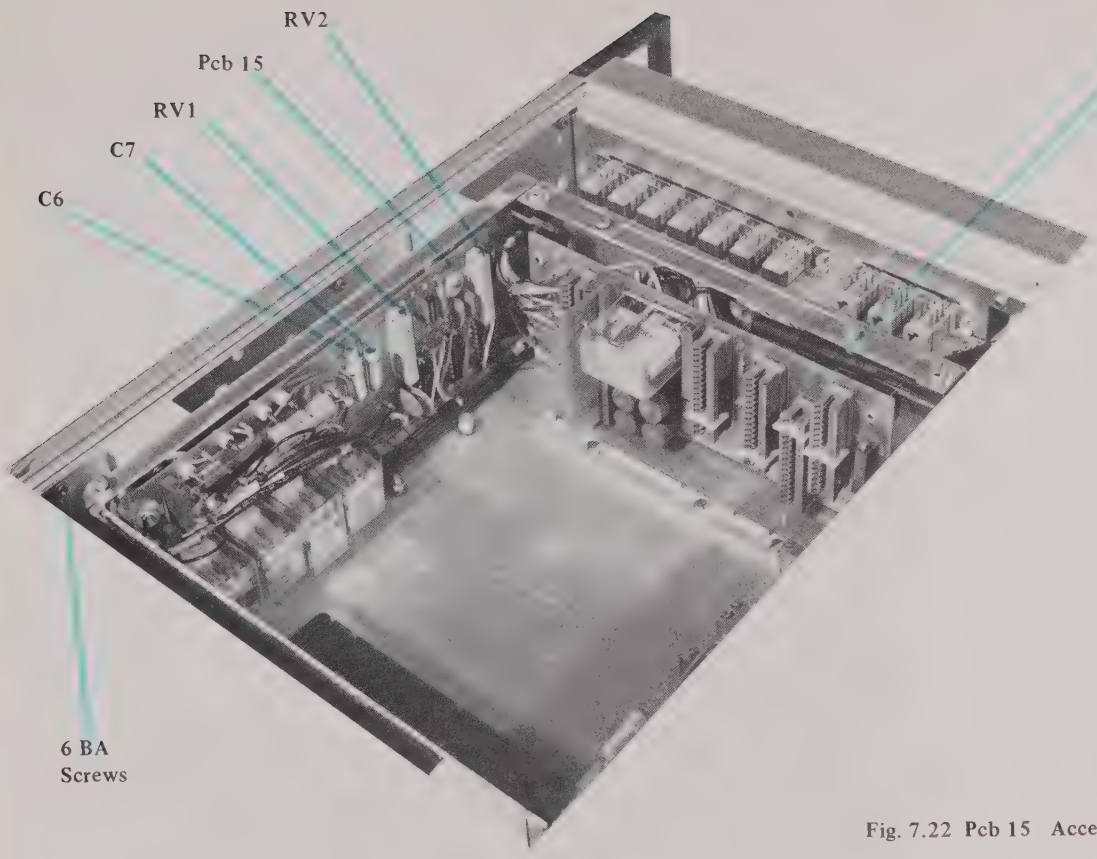



Fig. 7.22 Pcb 15 Access

For access to the copper side, remove the three 6 BA screws; two at the top and one bottom centre. Hi 1Ω (Red) Hi 2V (Yellow) Lo 2V (Green) Lo 1Ω (Blue) Guard (Black) from the Input Socket (Front Panel) are located on the copper side of Pcb 15.

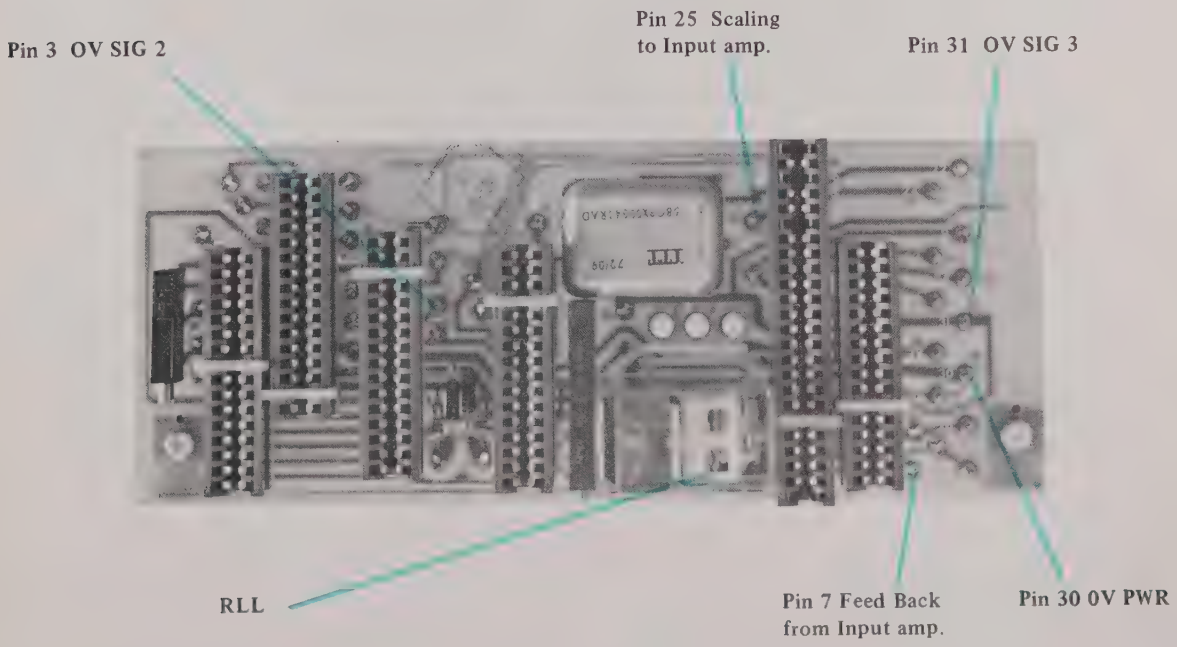
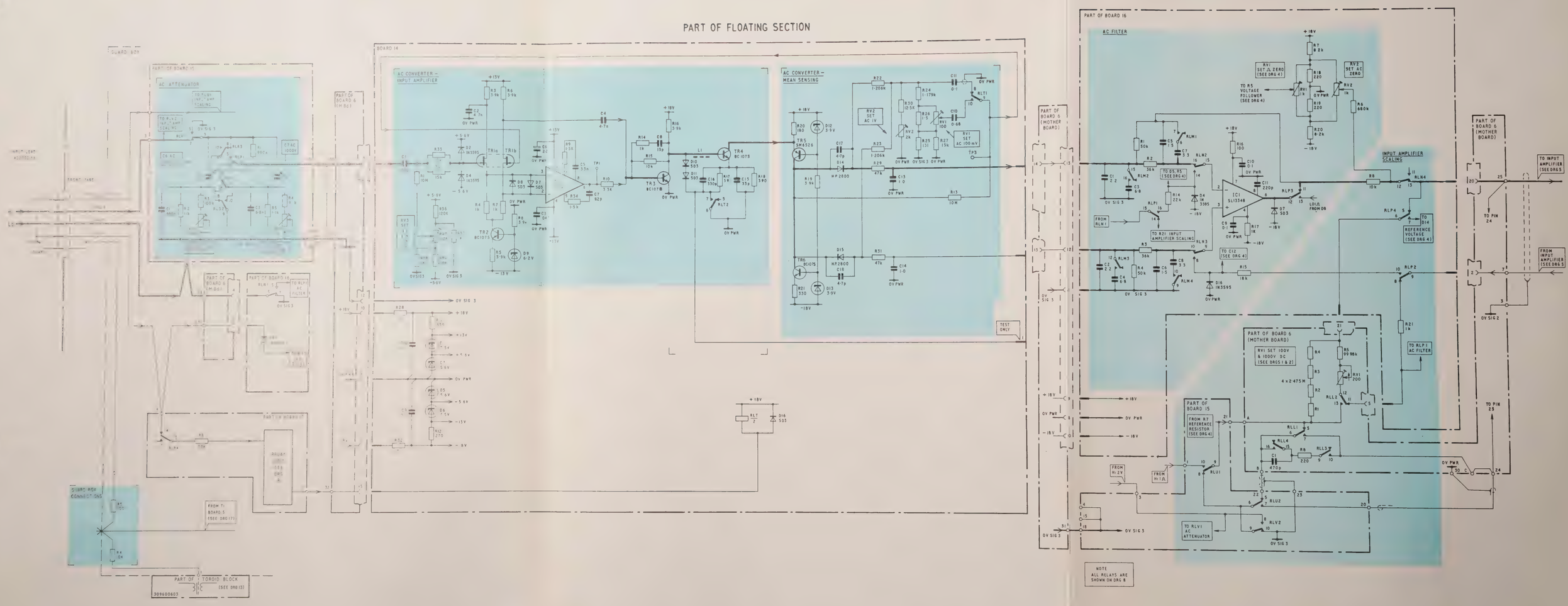



Fig. 7.23 Pcb 6 (A223)


PART OF FLOATING SECTION
BOARD 14
AC CONVERTER – INPUT AMPLIFIER
AC CONVERTER – MEAN SENSING
PART OF BOARD 16
AC FILTER
INPUT AMPLIFIER SCALING
PART OF BOARD 6 (MOTHER BOARD)
PART OF BOARD 15
AC ATTENUATOR
PART OF TOROID BLOCK (SEE DRG 13)
TEST ONLY
NOTE ALL RELAYS ARE SHOWN ON DRG 8

# AC INPUT (MEAN SENSING) CIRCUIT 3a

MR/A200/4

7.3.6

## DRG. 3b AC CONVERTER (TRUE RMS)

Drg. 3b of this supplement shows the complete circuit diagram for Board 41, the true rms ac converter, and it complements with Drg. 3a.

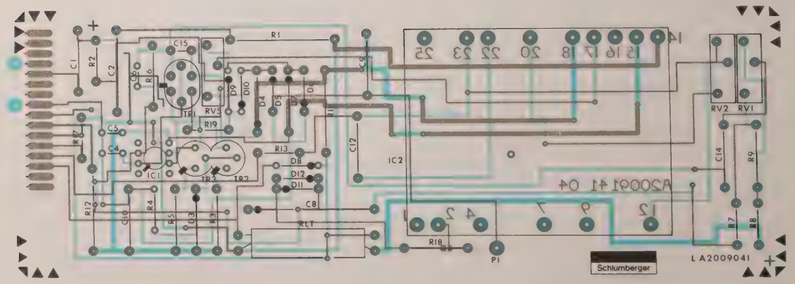
## PRINTED CIRCUIT BOARD 41 (A2009041)

True RMS measurement is performed by boards 15 and 41, Board 15, the AC Auxiliary board is the same as that used in DVM Types A203 and A223. Board 41, True RMS Converter, contains the true rms computing encapsulated module and this board is directly substituted for board 14 (Mean Sensing Converter) in DVM Types A205 and A225.

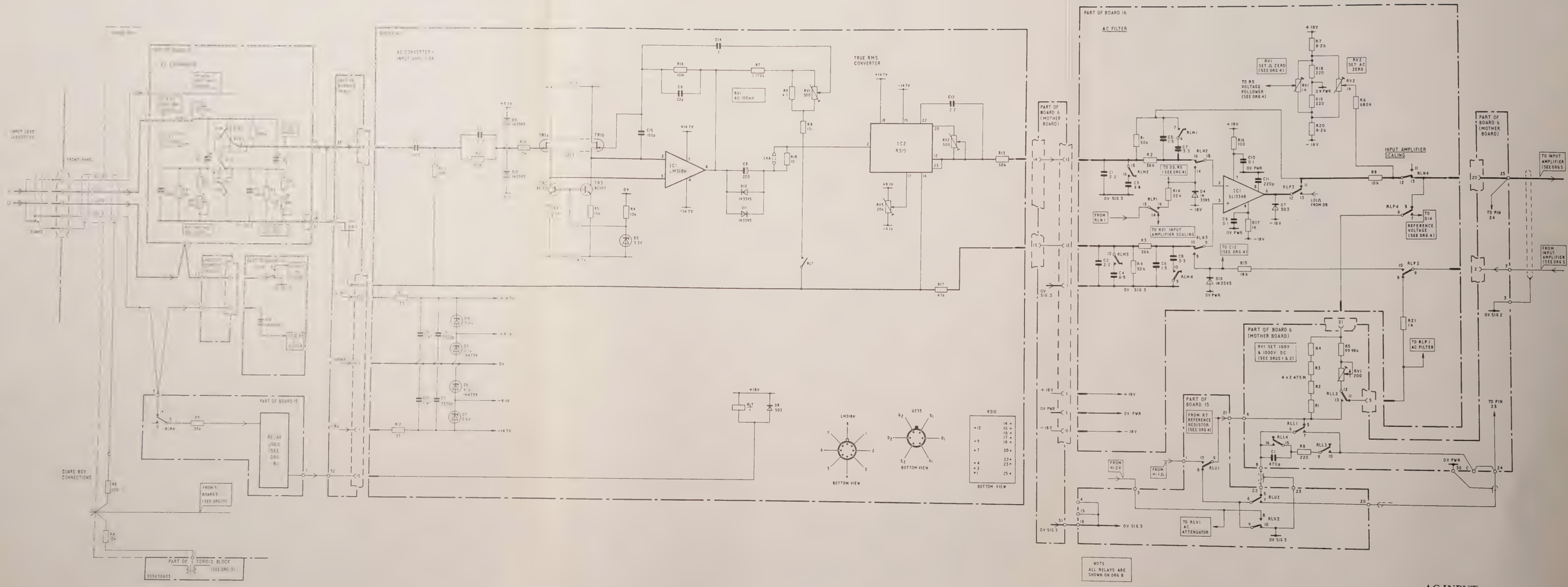
## PCB LOCATIONS

### DVM TYPES A205 AND A225

Refer to Fig. 7.15, Section 7.3.2, and substitute PCB 41 for PCB 14.

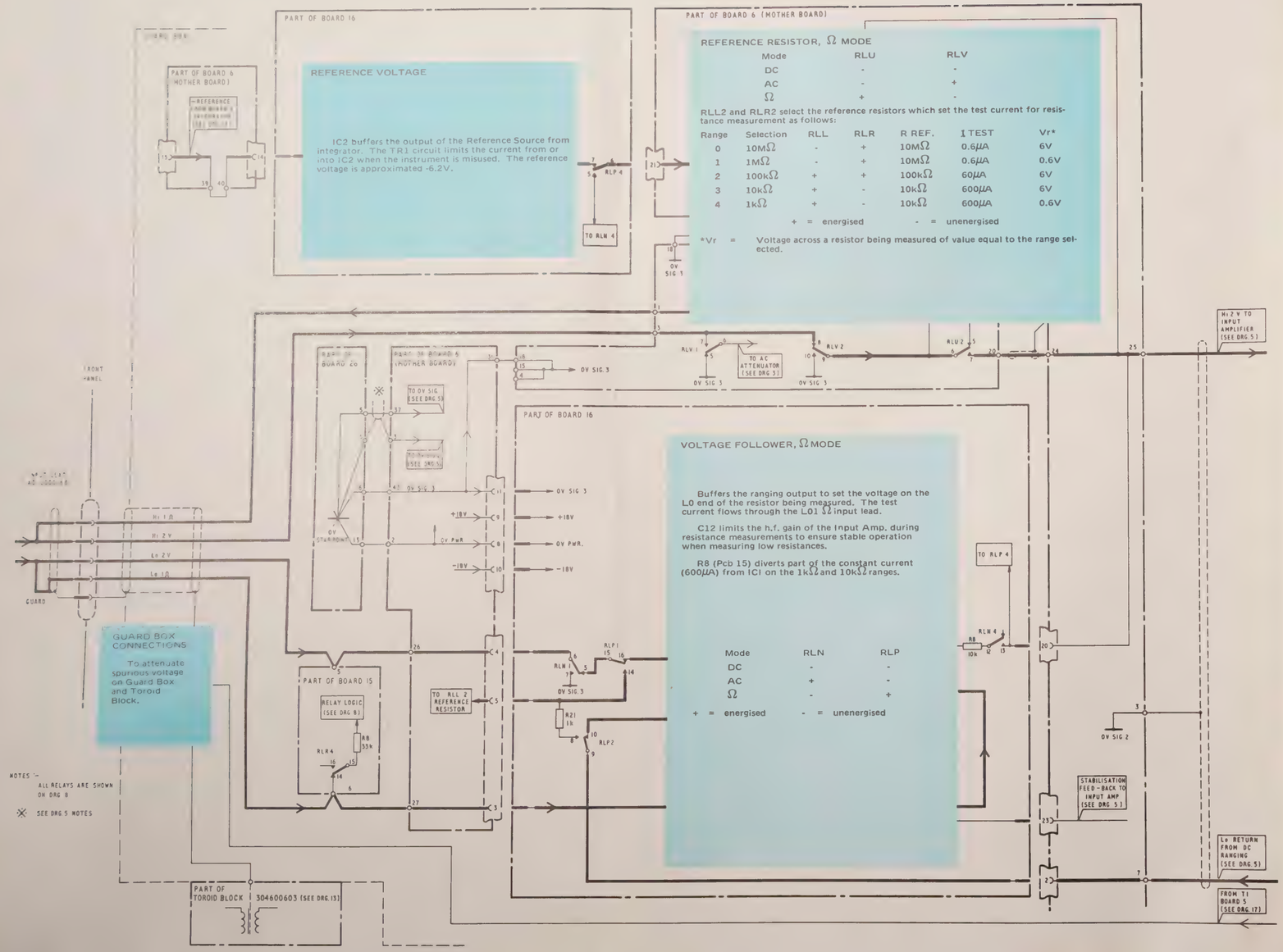



**Component layout pcb No. 41**




**AC INPUT (RMS SENSING) CIRCUIT** **3b**

JR/A200/2


PART OF BOARD 16
PART OF BOARD 6 (MOTHER BOARD)
REFERENCE VOLTAGE
IC2 buffers the output of the Reference Source from integrator. The TR1 circuit limits the current from or into IC2 when the instrument is misused. The reference voltage is approximated -6.2V.
REFERENCE RESISTOR, Ω MODE
Mode RLU RLV
DC - -
AC - +
Ω + -
RLL2 and RLR2 select the reference resistors which set the test current for resistance measurement as follows:
Range Selection RLL RLR R REF. I TEST Vr*
0 10MΩ - + 10MΩ 0.6μA 6V
1 1MΩ - + 10MΩ 0.6μA 0.6V
2 100kΩ + + 100kΩ 60μA 6V
3 10kΩ + - 10kΩ 600μA 6V
4 1kΩ + - 10kΩ 600μA 0.6V
+ = energised - = unenergised
*Vr = Voltage across a resistor being measured of value equal to the range selected.
TO RLN 4
TO RLP 4
TO AC ATTENUATOR (SEE DRG 3)
0V SIG 3
HI 2V TO INPUT AMPLIFIER (SEE DRG 5)
FRONT PANEL
GUARD
HI 1Ω
HI 2V
LO 2V
LO 1Ω
GUARD BOX CONNECTIONS
To attenuate spurious voltage on Guard Box and Toroid Block.
PART OF BOARD 16
VOLTAGE FOLLOWER, Ω MODE
Buffers the ranging output to set the voltage on the LO end of the resistor being measured. The test current flows through the LO1 Ω input lead.
C12 limits the h.f. gain of the Input Amp. during resistance measurements to ensure stable operation when measuring low resistances.
R8 (Pcb 15) diverts part of the constant current (600μA) from IC1 on the 1kΩ and 10kΩ ranges.
Mode RLN RLP
DC - -
AC + -
Ω - +
+ = energised - = unenergised
+18V
-18V
0V PWR.
0V STARPOINT
PART OF BOARD 15
RELAY LOGIC (SEE DRG 8)
TO RLL 2 REFERENCE RESISTOR
STABILISATION FEED-BACK TO INPUT AMP (SEE DRG 5)
Lo RETURN FROM DC RANGING (SEE DRG 5)
FROM T1 BOARD 5 (SEE DRG 17)
PART OF TOROID BLOCK 304600603 (SEE DRG 13)
NOTES :-
ALL RELAYS ARE SHOWN ON DRG 8
SEE DRG 5 NOTES

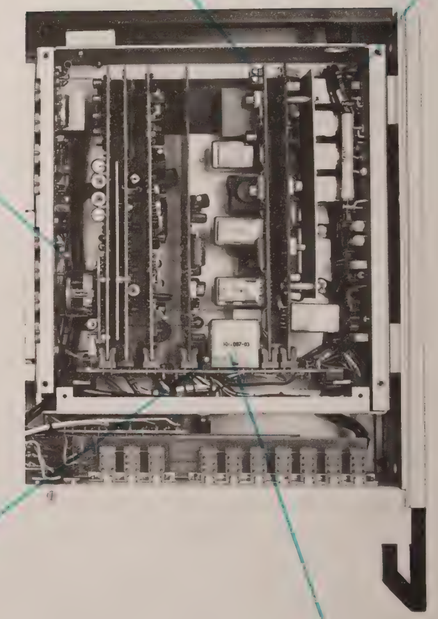



Fig. 7.24 Pcb's 26, 16, 15 and 6

## Ω INPUT (A203 AND A223) DESCRIPTION 4

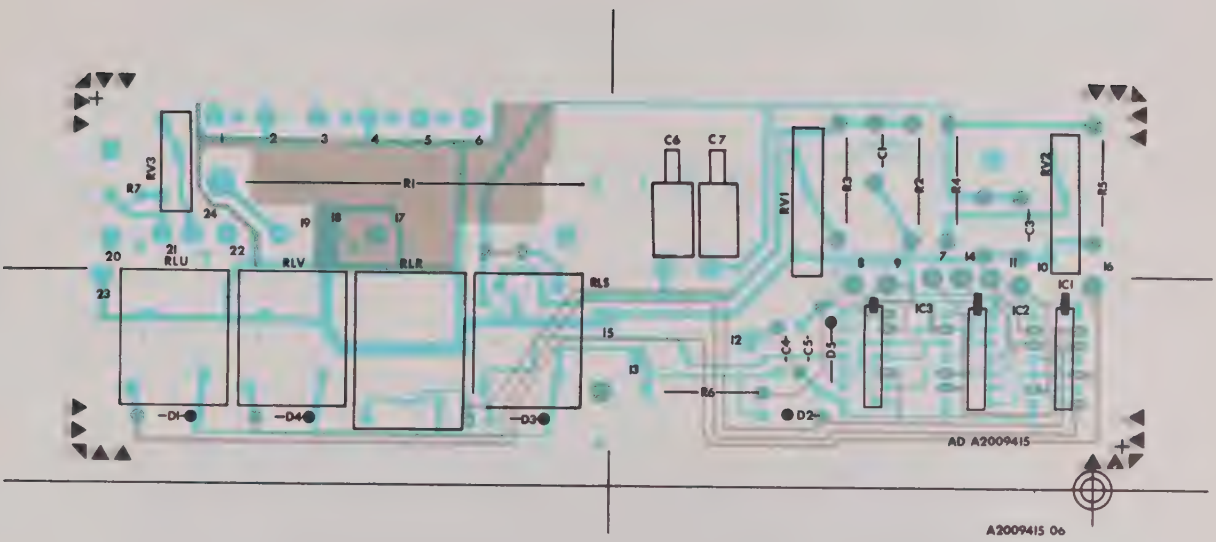



Fig. 7.25 Pcb 15

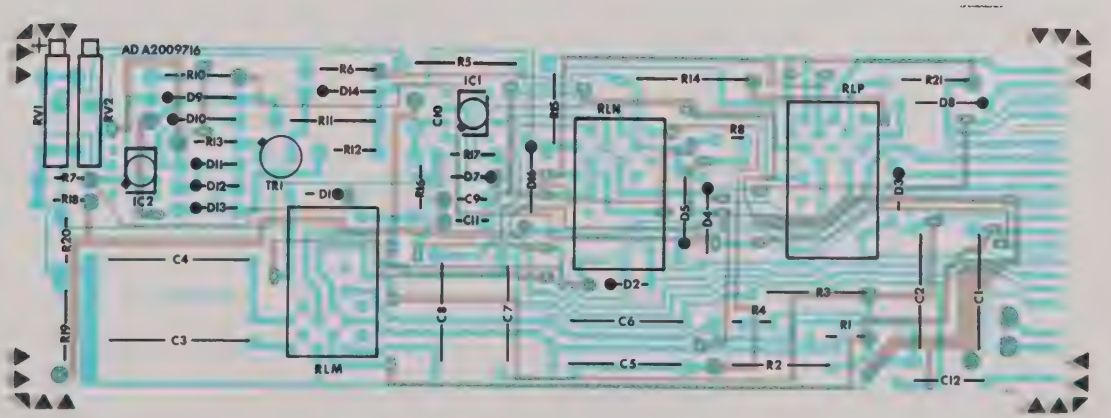



Fig. 7.27 Pcb 16

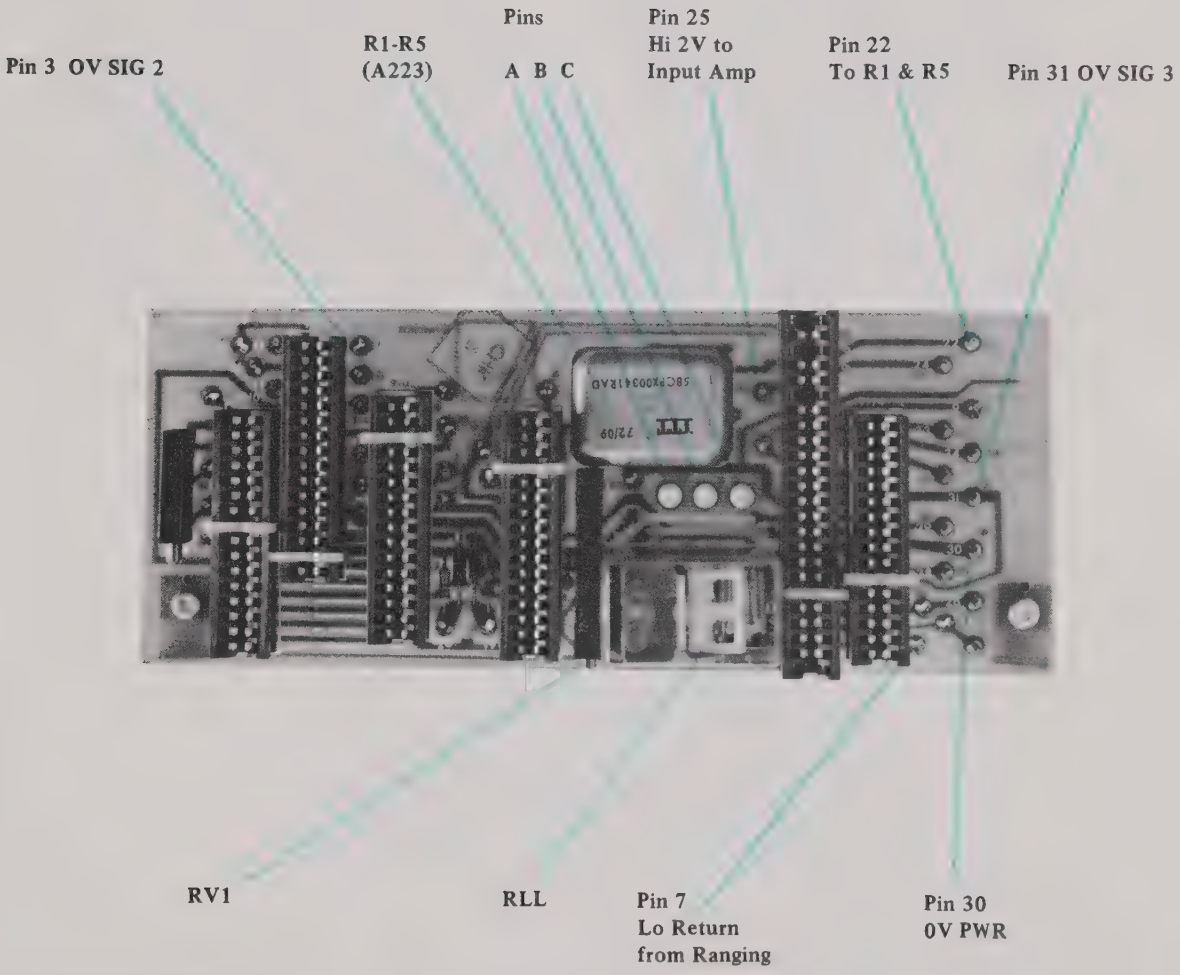
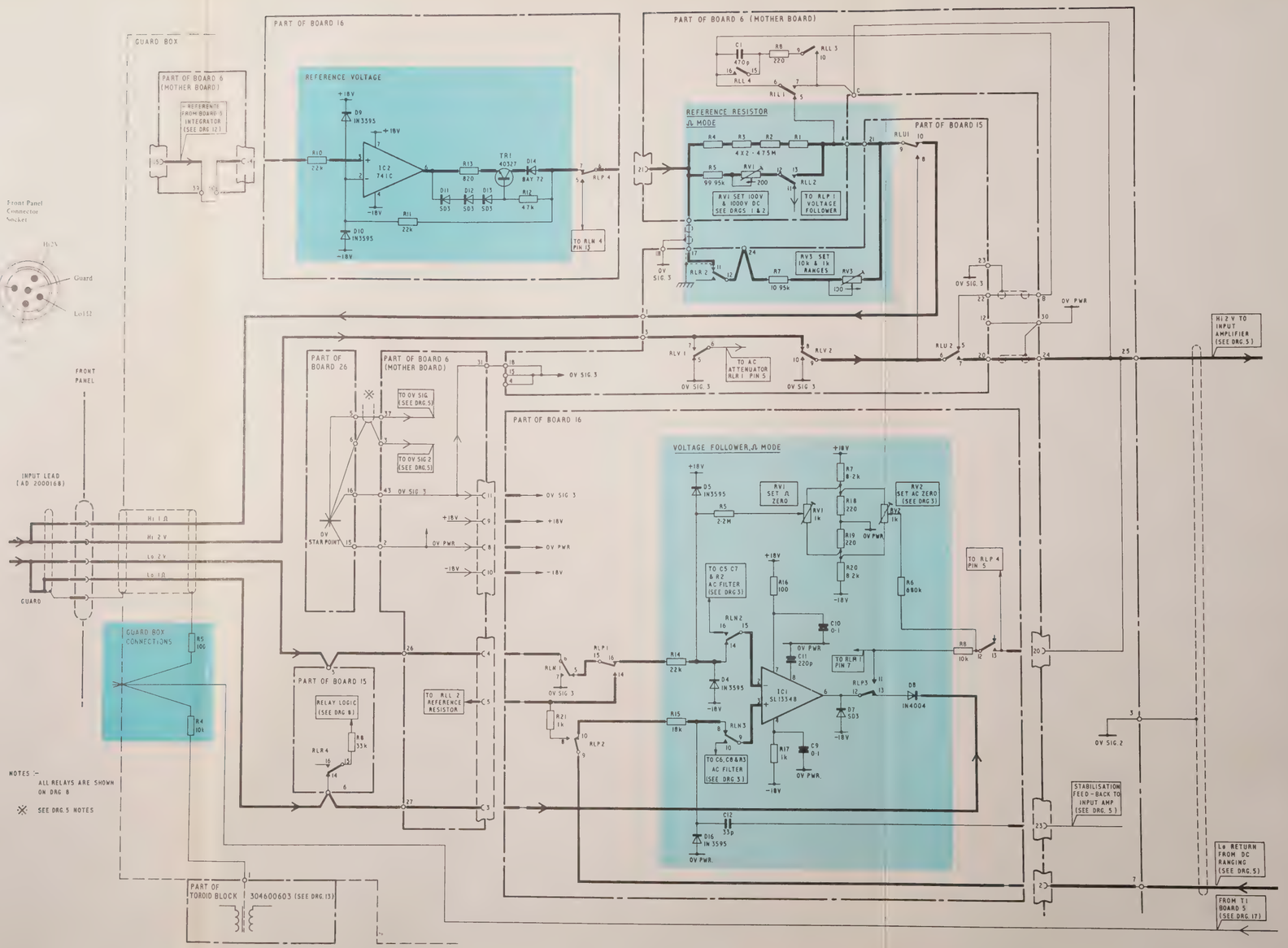


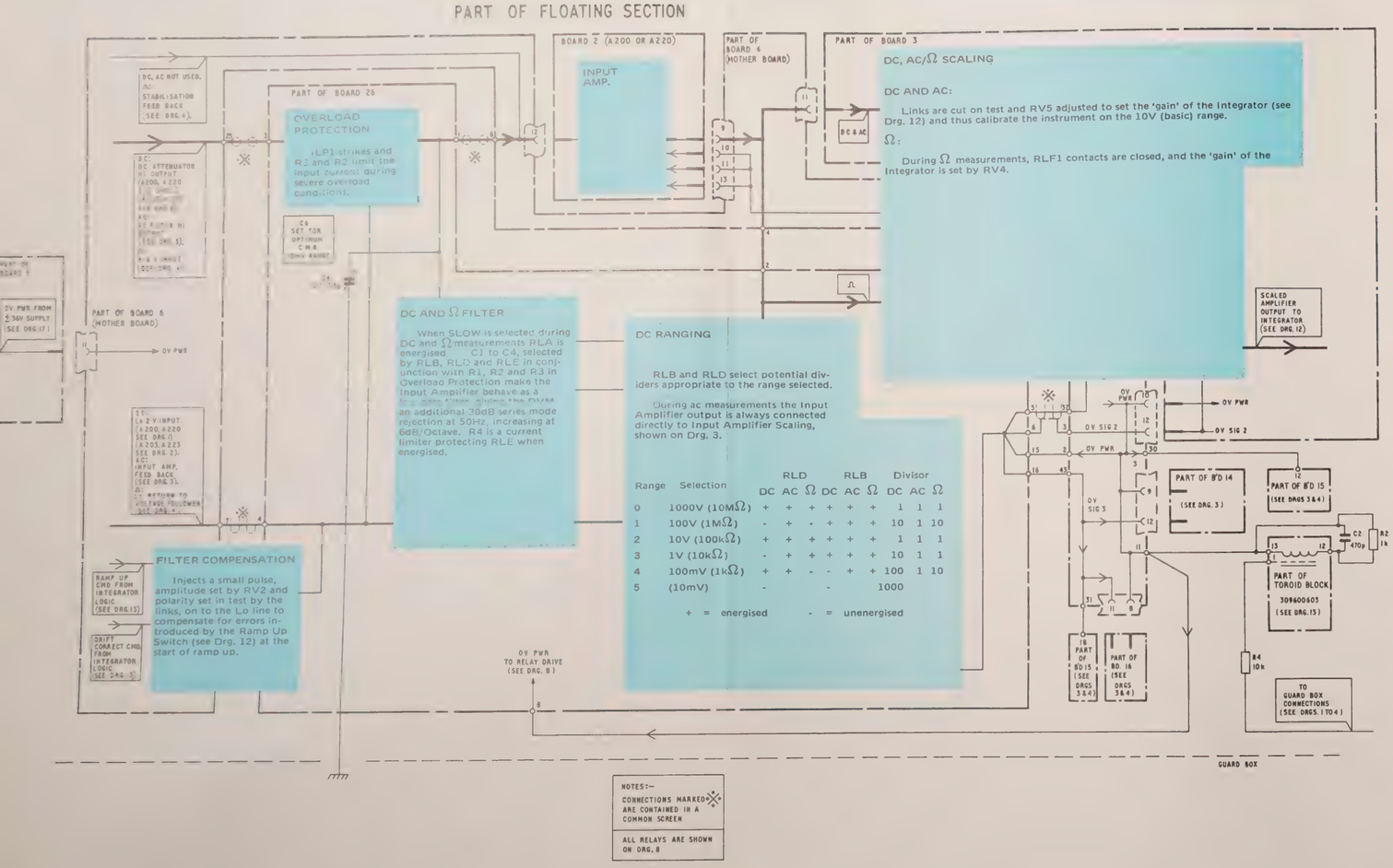

Fig. 7.29 Pcb 6 (Component Side)




Ω INPUT CIRCUIT 4

JR/A200/2

7.4.4


PART OF FLOATING SECTION
BOARD 2 (A200 OR A220)
PART OF BOARD 6 (MOTHER BOARD)
PART OF BOARD 3
PART OF BOARD 26
INPUT AMP.
OVERLOAD PROTECTION
LP1 strikes and R3 and R2 limit the input current during severe overload conditions.
DC, AC/Ω SCALING
DC AND AC:
Links are cut on test and RV5 adjusted to set the 'gain' of the integrator (see Drg. 12) and thus calibrate the instrument on the 10V (basic) range.
Ω:
During Ω measurements, RLF1 contacts are closed, and the 'gain' of the integrator is set by RV4.
DC AND Ω FILTER
When SLOW is selected during DC and Ω measurements RLA is energised. C1 to C4, selected by RLB, RLC and RLE in conjunction with R1, R2 and R3 in Overload Protection make the Input Amplifier behave as a [illegible] an additional 30dB series mode rejection at 50Hz, increasing at 6dB/Octave. R4 is a current limiter protecting RLE when energised.
DC RANGING
RLB and RLD select potential dividers appropriate to the range selected.
During ac measurements the Input Amplifier output is always connected directly to Input Amplifier Scaling, shown on Drg. 3.
Range Selection RLD DC AC Ω RLB DC AC Ω Divisor DC AC Ω
0 1000V (10MΩ) + + + + + + 1 1 1
1 100V (1MΩ) - + - + + + 10 1 10
2 10V (100kΩ) + + + + + + 1 1 1
3 1V (10kΩ) - + + + + + 10 1 1
4 100mV (1kΩ) + + - - + + 100 1 10
5 (10mV) - - 1000
+ = energised - = unenergised
FILTER COMPENSATION
Injects a small pulse, amplitude set by RV2 and polarity set in test by the links, on to the Lo line to compensate for errors introduced by the Ramp Up Switch (see Drg. 12) at the start of ramp up.
SCALED AMPLIFIER OUTPUT TO INTEGRATOR (SEE DRG. 12)
OV PWR
OV SIG 2
OV SIG 3
PART OF BD 14 (SEE DRG. 3)
PART OF BD 15 (SEE DRGS 3&4)
PART OF TOROID BLOCK 30960603 (SEE DRG. 15)
PART OF BD 15 (SEE DRGS 3&4)
PART OF BD. 16 (SEE DRGS 3&4)
TO GUARD BOX CONNECTIONS (SEE DRGS. 1 TO 4)
OV PWR TO RELAY DRIVE (SEE DRG. 8)
GUARD BOX
NOTES:-
CONNECTIONS MARKED ※ ARE CONTAINED IN A COMMON SCREEN
ALL RELAYS ARE SHOWN ON DRG. 8

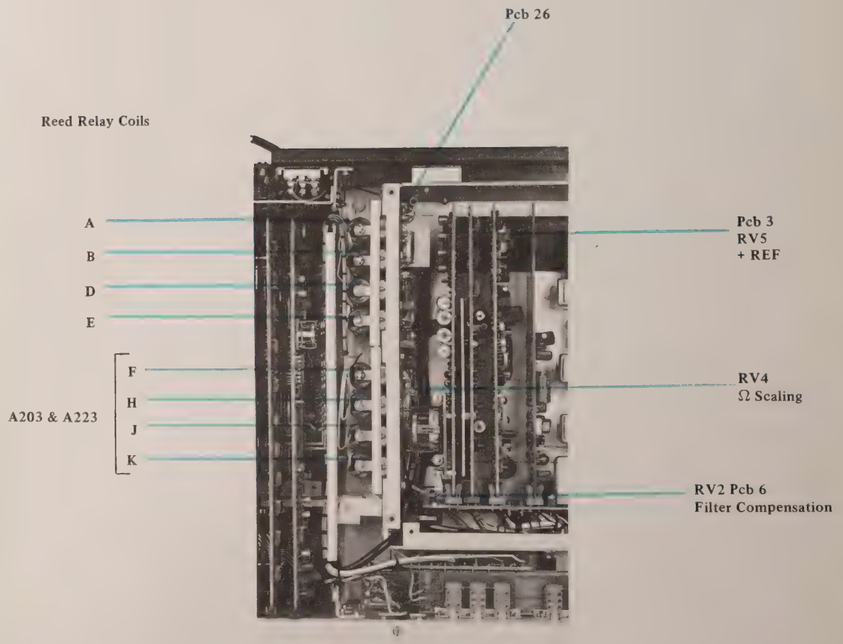



Fig. 7.30 Pcb 26 and Reed Relay Coils

INPUT AMPLIFIER CONNECTION DESCRIPTION 5

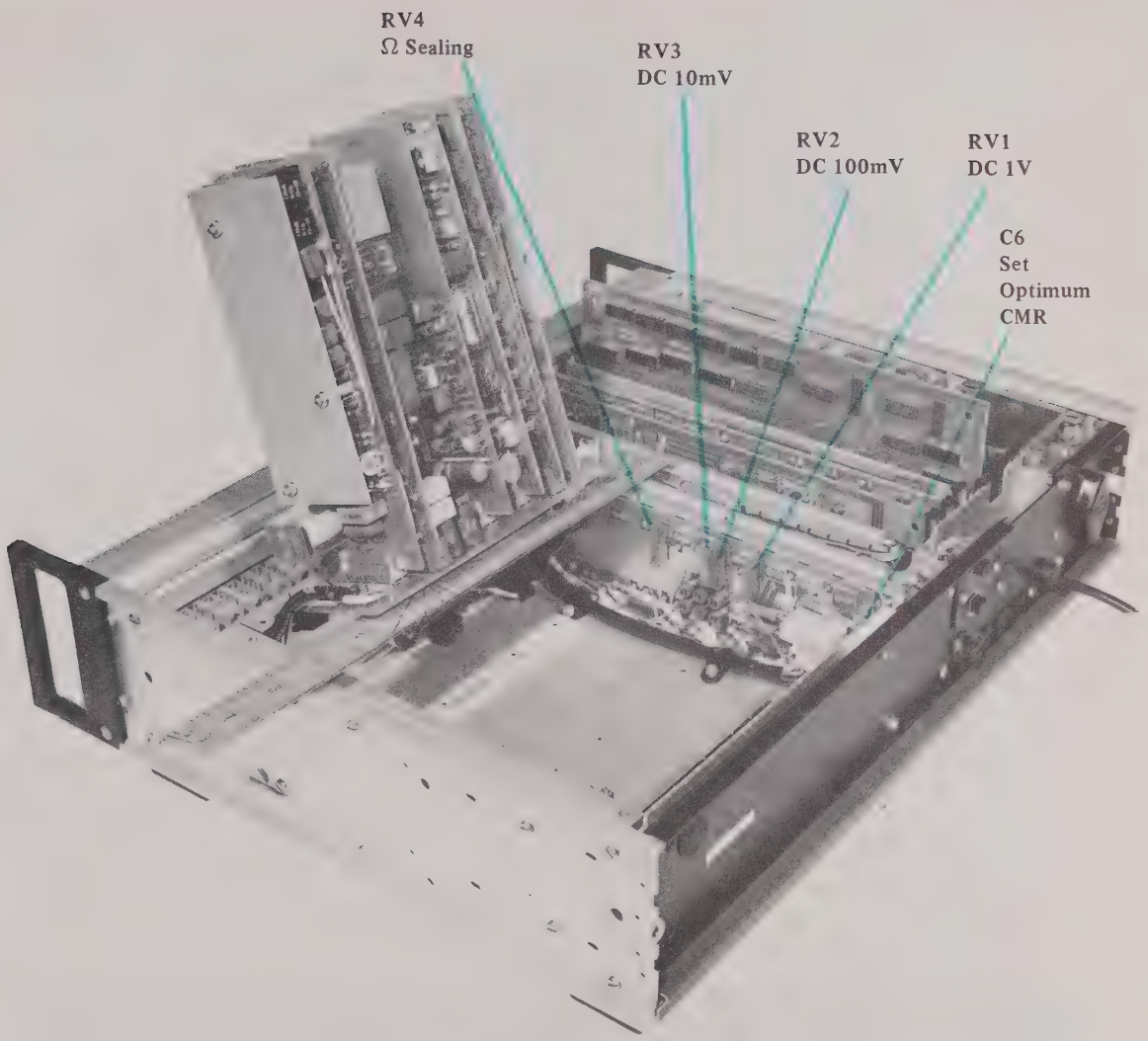



Fig. 7.31 Access to Pcb 26

With the Floating Section Cover removed, Pcb 6 with Pcb's 5,4,3,2, 16 (or.31) and 14 may be pivoted clear of the instrument and supported as shown.

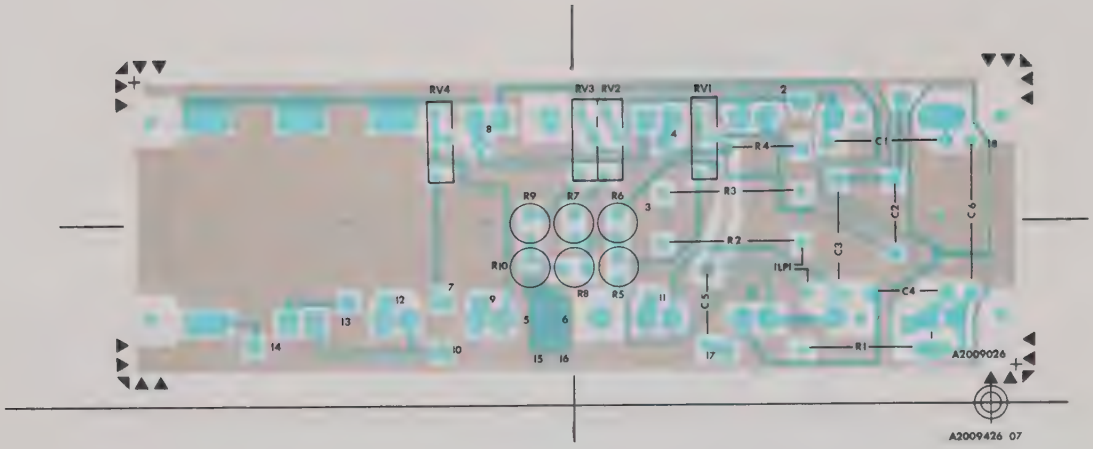



Fig. 7.32 Pcb 26

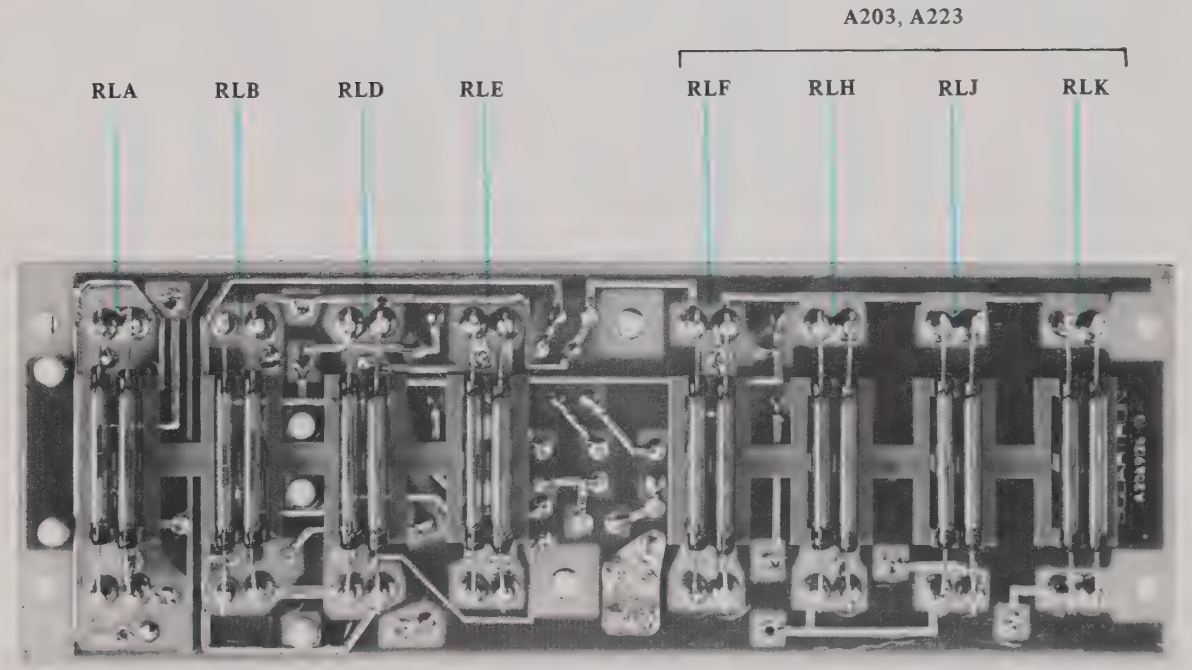
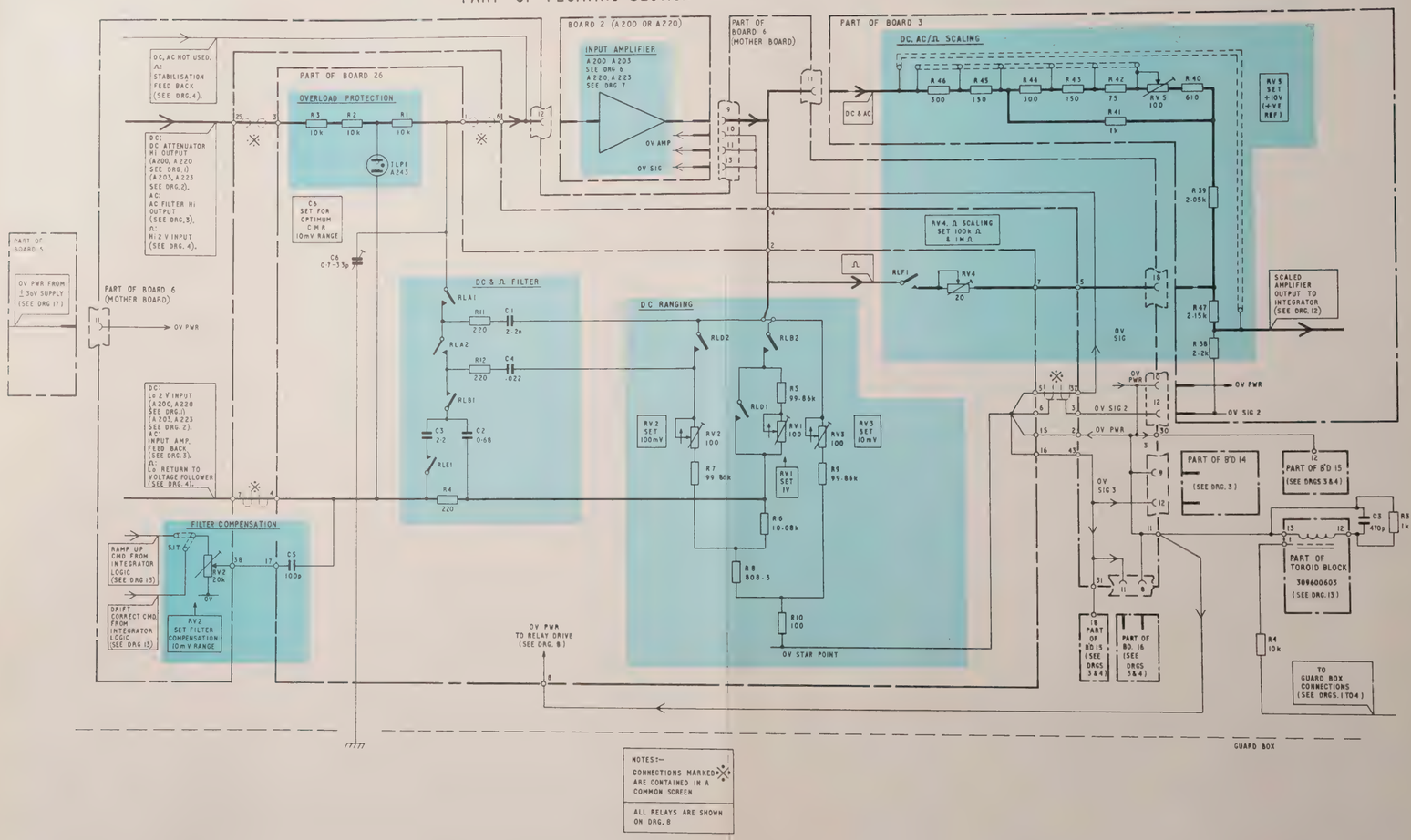



Fig. 7.34 Pcb 26. Copper Side and Reed Relay Contacts

Fig. 7.35 Pcb 3

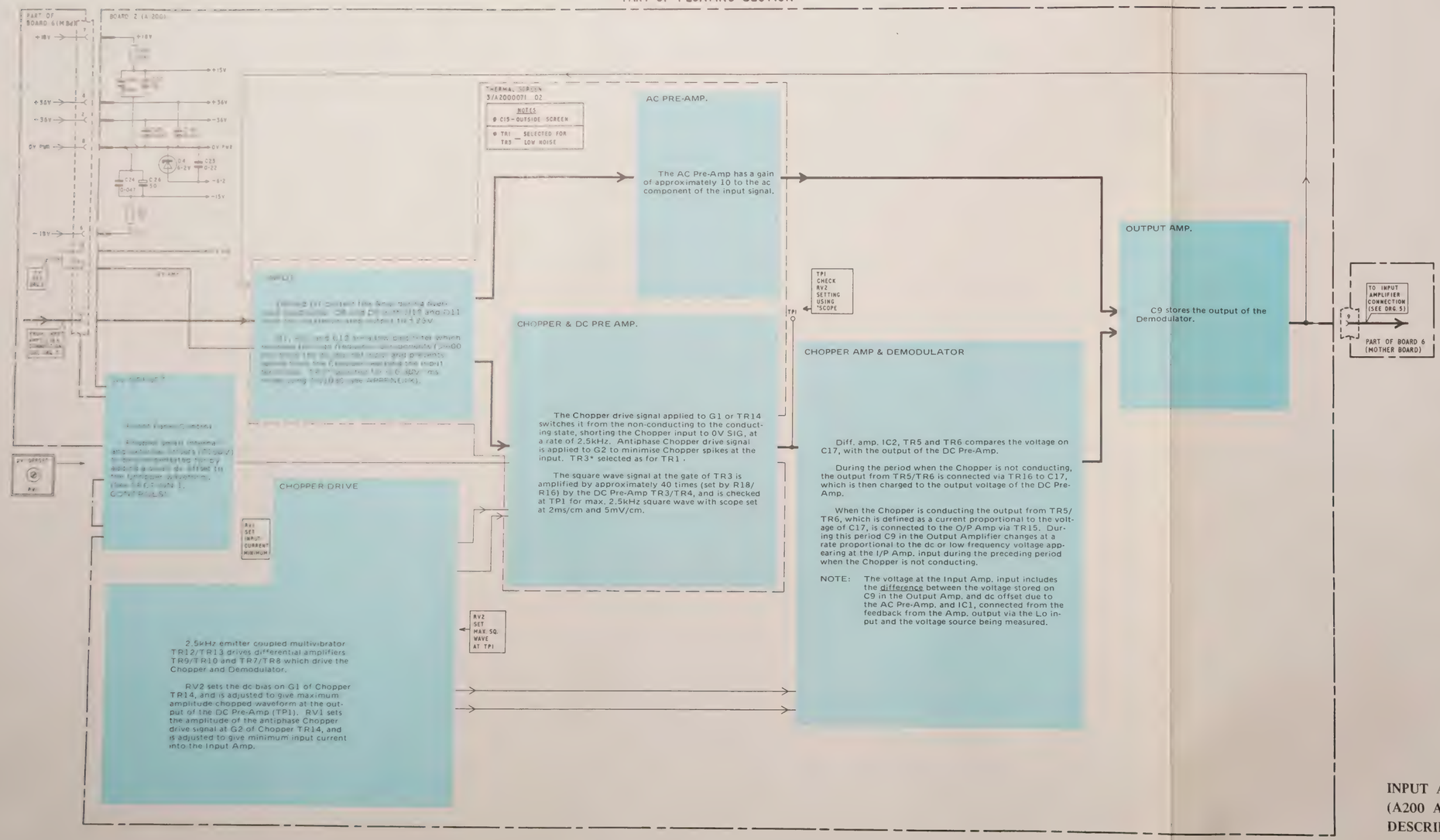
Scaled Amplifier Output to INTEGRATOR (see DRG 12) is 6.4V for a "19999" DVM Input, and is -VE for a +VE Input.

PART OF FLOATING SECTION




INPUT AMPLIFIER CONNECTION CIRCUIT

5


PART OF FLOATING SECTION
PART OF BOARD 6 (MB6)
BOARD 2 (A200)
+18V
+15V
+36V
-36V
0V PWR
-18V
-15V
THERMAL SCREEN 3/A2000071 02
NOTES
1. C15 - OUTSIDE SCREEN
2. TR1 TR3 - SELECTED FOR LOW NOISE
AC PRE-AMP.
The AC Pre-Amp has a gain of approximately 10 to the ac component of the input signal.
INPUT
CHOPPER & DC PRE AMP.
The Chopper drive signal applied to G1 or TR14 switches it from the non-conducting to the conducting state, shorting the Chopper input to 0V SIG, at a rate of 2.5kHz. Antiphase Chopper drive signal is applied to G2 to minimise Chopper spikes at the input. TR3* selected as for TR1.
The square wave signal at the gate of TR3 is amplified by approximately 40 times (set by R18/R16) by the DC Pre-Amp TR3/TR4, and is checked at TP1 for max. 2.5kHz square wave with scope set at 2ms/cm and 5mV/cm.
TP1
TP1 CHECK RV2 SETTING USING 'SCOPE
CHOPPER AMP & DEMODULATOR
Diff. amp. IC2, TR5 and TR6 compares the voltage on C17, with the output of the DC Pre-Amp.
During the period when the Chopper is not conducting, the output from TR5/TR6 is connected via TR16 to C17, which is then charged to the output voltage of the DC Pre-Amp.
When the Chopper is conducting the output from TR5/TR6, which is defined as a current proportional to the voltage of C17, is connected to the O/P Amp via TR15. During this period C9 in the Output Amplifier changes at a rate proportional to the dc or low frequency voltage appearing at the I/P Amp. input during the preceding period when the Chopper is not conducting.
NOTE: The voltage at the Input Amp. input includes the difference between the voltage stored on C9 in the Output Amp. and dc offset due to the AC Pre-Amp. and IC1, connected from the feedback from the Amp. output via the Lo input and the voltage source being measured.
OUTPUT AMP.
C9 stores the output of the Demodulator.
TO INPUT AMPLIFIER CONNECTION (SEE DRG 5)
PART OF BOARD 6 (MOTHER BOARD)
CHOPPER DRIVE
2.5kHz emitter coupled multivibrator TR12/TR13 drives differential amplifiers TR9/TR10 and TR7/TR8 which drive the Chopper and Demodulator.
RV2 sets the dc bias on G1 of Chopper TR14, and is adjusted to give maximum amplitude chopped waveform at the output of the DC Pre-Amp (TP1). RV1 sets the amplitude of the antiphase Chopper drive signal at G2 of Chopper TR14, and is adjusted to give minimum input current into the Input Amp.
RV1 SET INPUT CURRENT MINIMUM
RV2 SET MAX SQ. WAVE AT TP1

# INPUT AMPLIFIER (A200 AND A203) DESCRIPTION 6

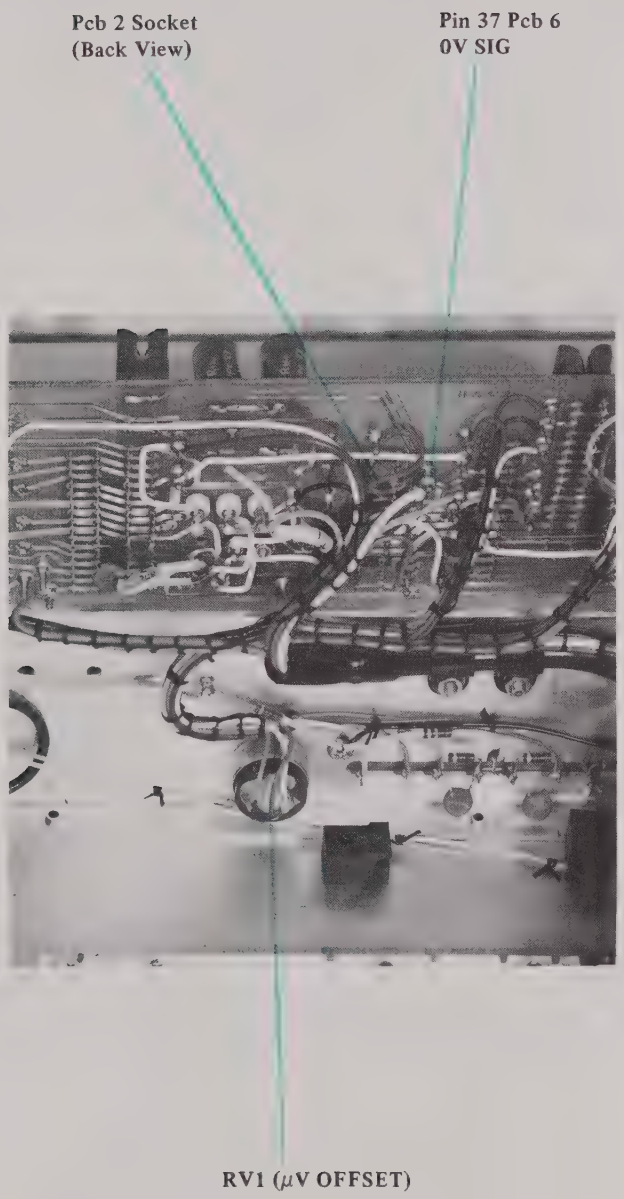



Fig. 7.37 Pcb 2 Socket and RV1 (μV OFFSET)

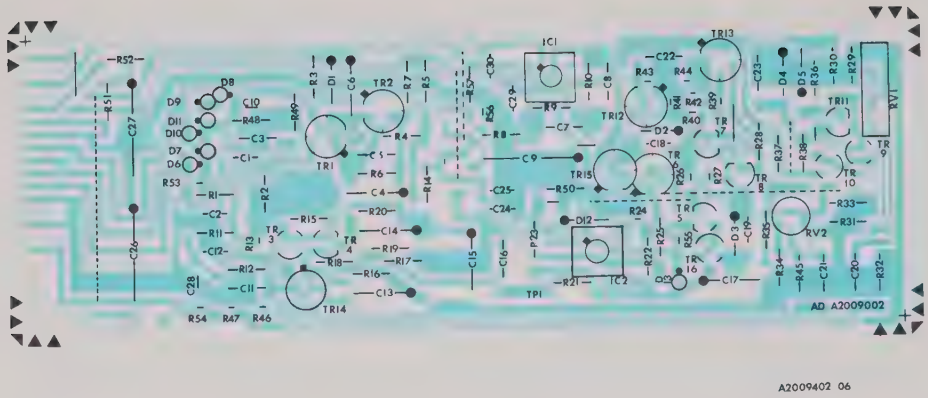



Fig. 7.38 Pcb 2

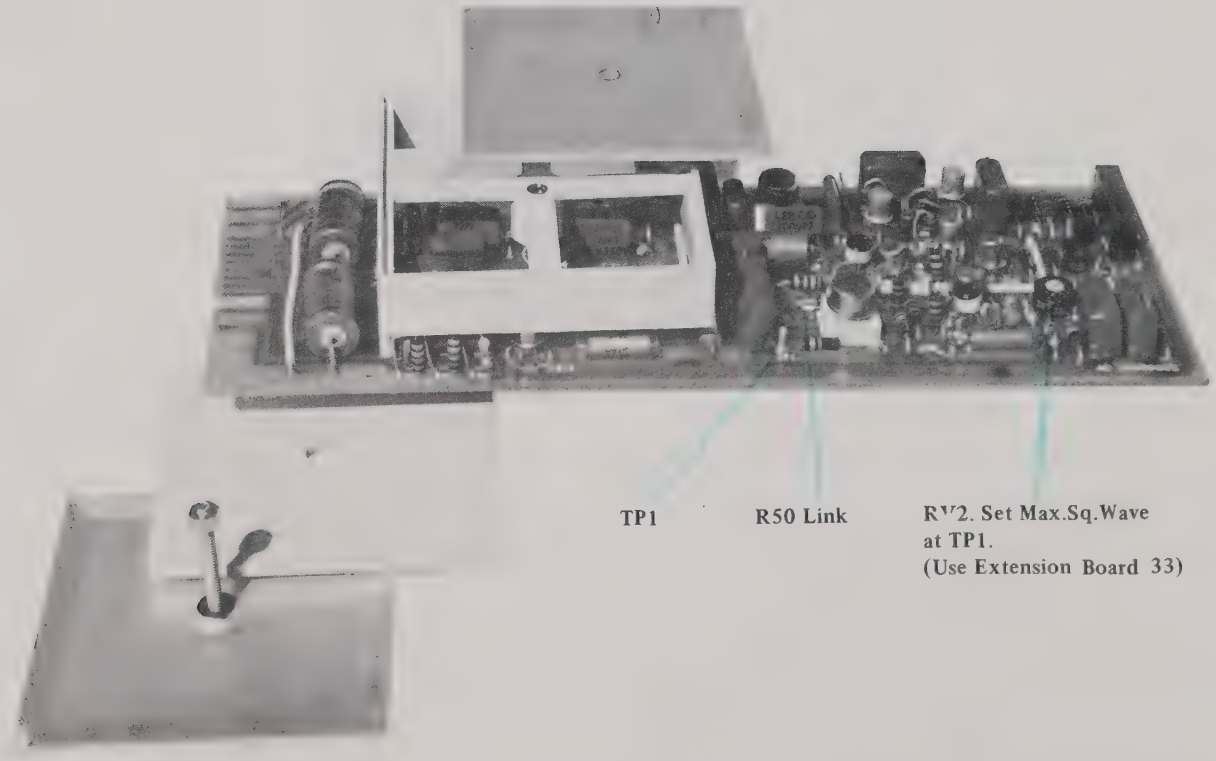
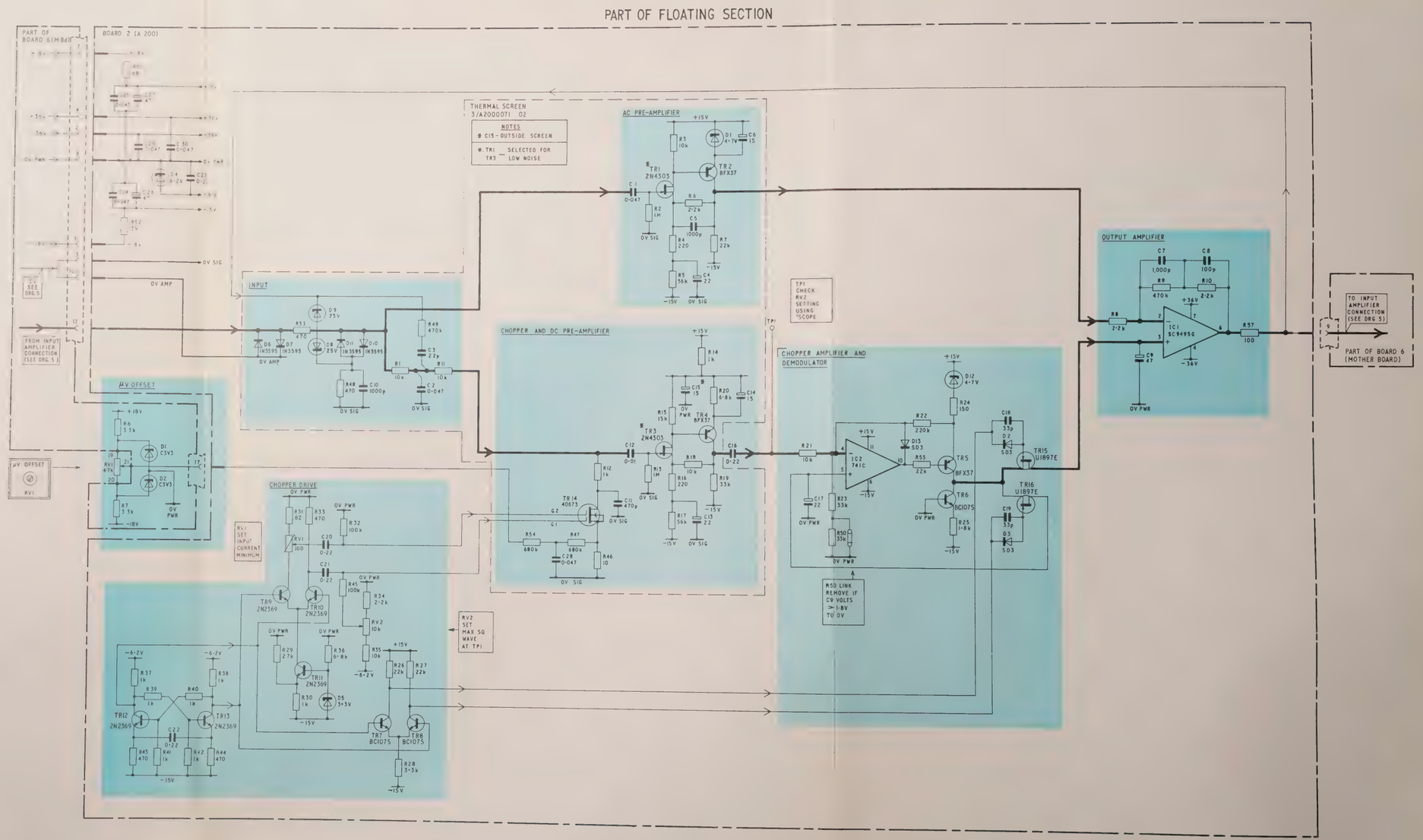



Fig. 7.40 Pcb 2, (A200, A203)
Thermal Screen Removal

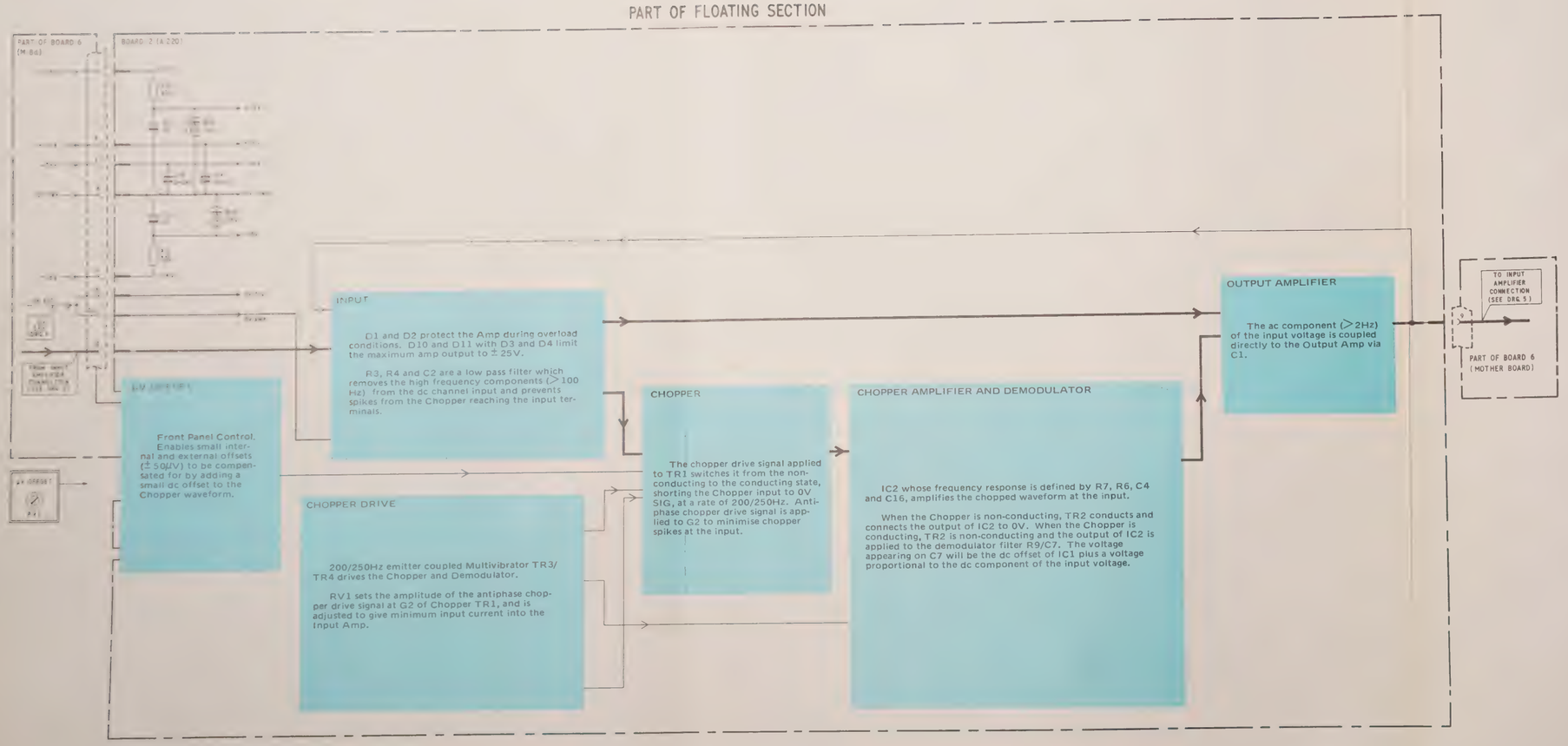



INPUT AMPLIFIER CIRCUIT ($1\mu V$)

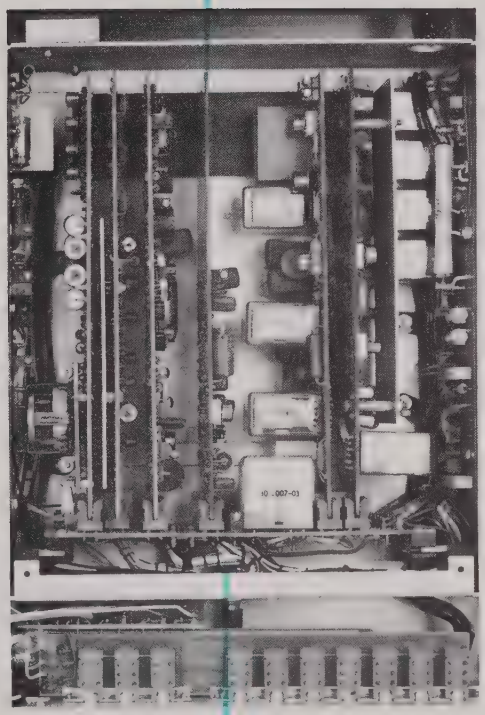
6

JR/A200/2

7.6.4


PART OF FLOATING SECTION
PART OF BOARD 6 (M-B6)
BOARD 2 (A220)
INPUT
D1 and D2 protect the Amp during overload conditions. D10 and D11 with D3 and D4 limit the maximum amp output to ± 25V.
R3, R4 and C2 are a low pass filter which removes the high frequency components (>100 Hz) from the dc channel input and prevents spikes from the Chopper reaching the input terminals.
Front Panel Control. Enables small internal and external offsets (±50μV) to be compensated for by adding a small dc offset to the Chopper waveform.
CHOPPER DRIVE
200/250Hz emitter coupled Multivibrator TR3/TR4 drives the Chopper and Demodulator.
RV1 sets the amplitude of the antiphase chopper drive signal at G2 of Chopper TR1, and is adjusted to give minimum input current into the Input Amp.
CHOPPER
The chopper drive signal applied to TR1 switches it from the non-conducting to the conducting state, shorting the Chopper input to 0V SIG, at a rate of 200/250Hz. Anti-phase chopper drive signal is applied to G2 to minimise chopper spikes at the input.
CHOPPER AMPLIFIER AND DEMODULATOR
IC2 whose frequency response is defined by R7, R6, C4 and C16, amplifies the chopped waveform at the input.
When the Chopper is non-conducting, TR2 conducts and connects the output of IC2 to 0V. When the Chopper is conducting, TR2 is non-conducting and the output of IC2 is applied to the demodulator filter R9/C7. The voltage appearing on C7 will be the dc offset of IC1 plus a voltage proportional to the dc component of the input voltage.
OUTPUT AMPLIFIER
The ac component (>2Hz) of the input voltage is coupled directly to the Output Amp via C1.
TO INPUT AMPLIFIER CONNECTION (SEE DRG 5)
PART OF BOARD 6 (MOTHER BOARD)

Pcb 2 (A220, A223)



RV1 ($\mu$V OFFSET)
Front Panel Control

Fig. 7.41 Pcb 2 (A220, A223)

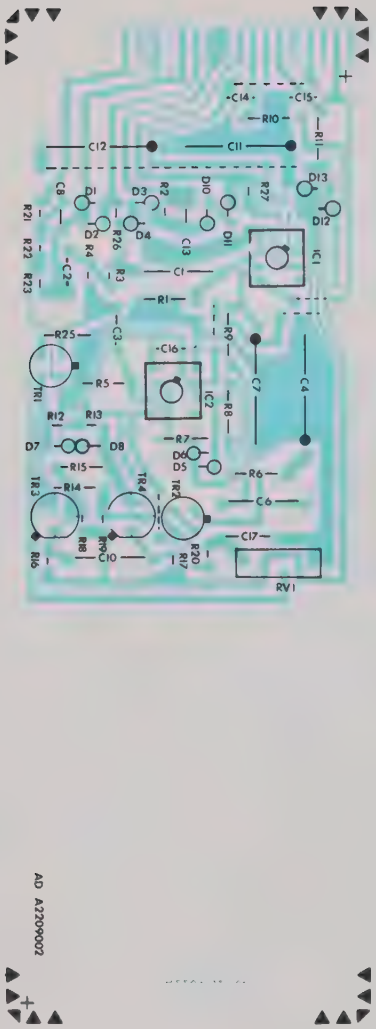
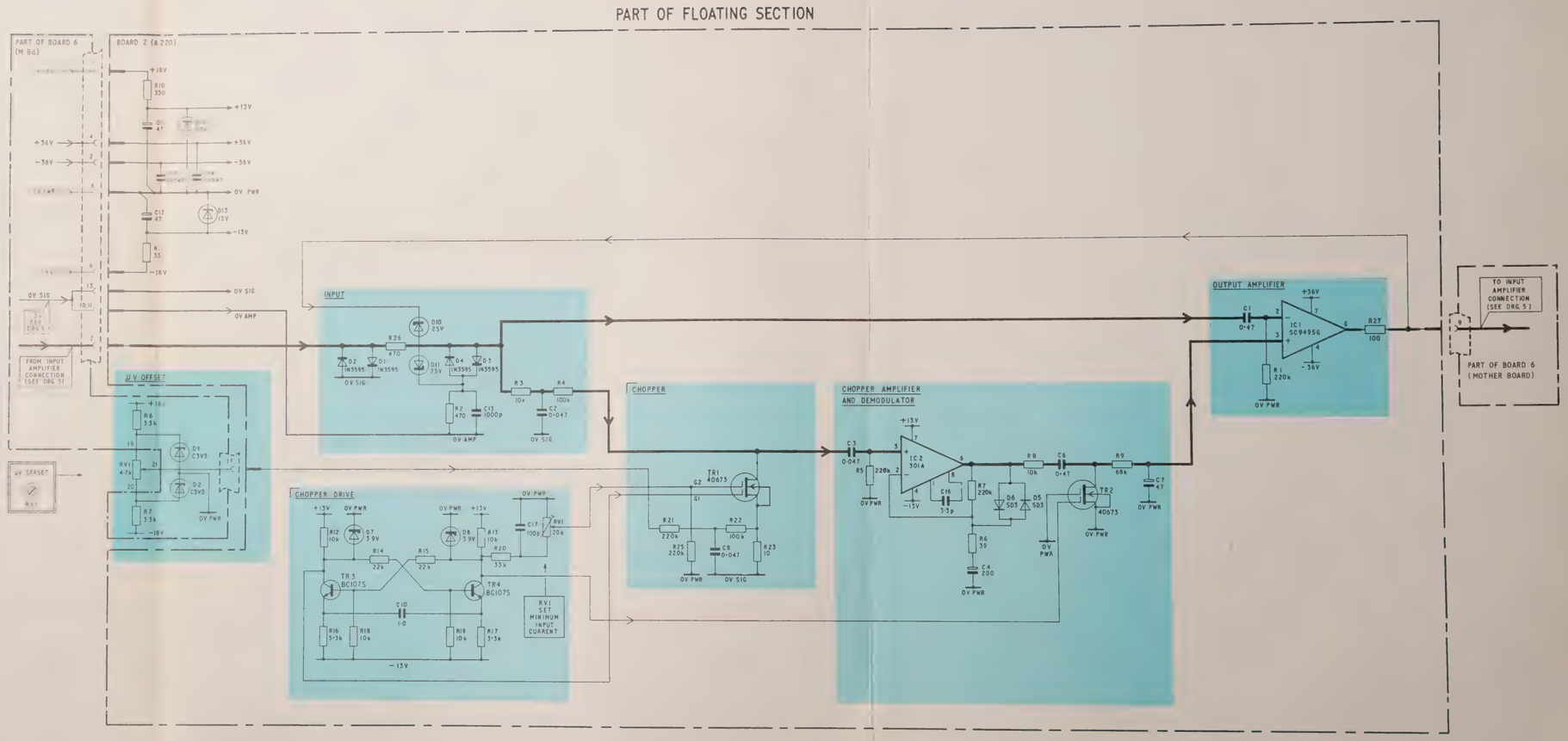


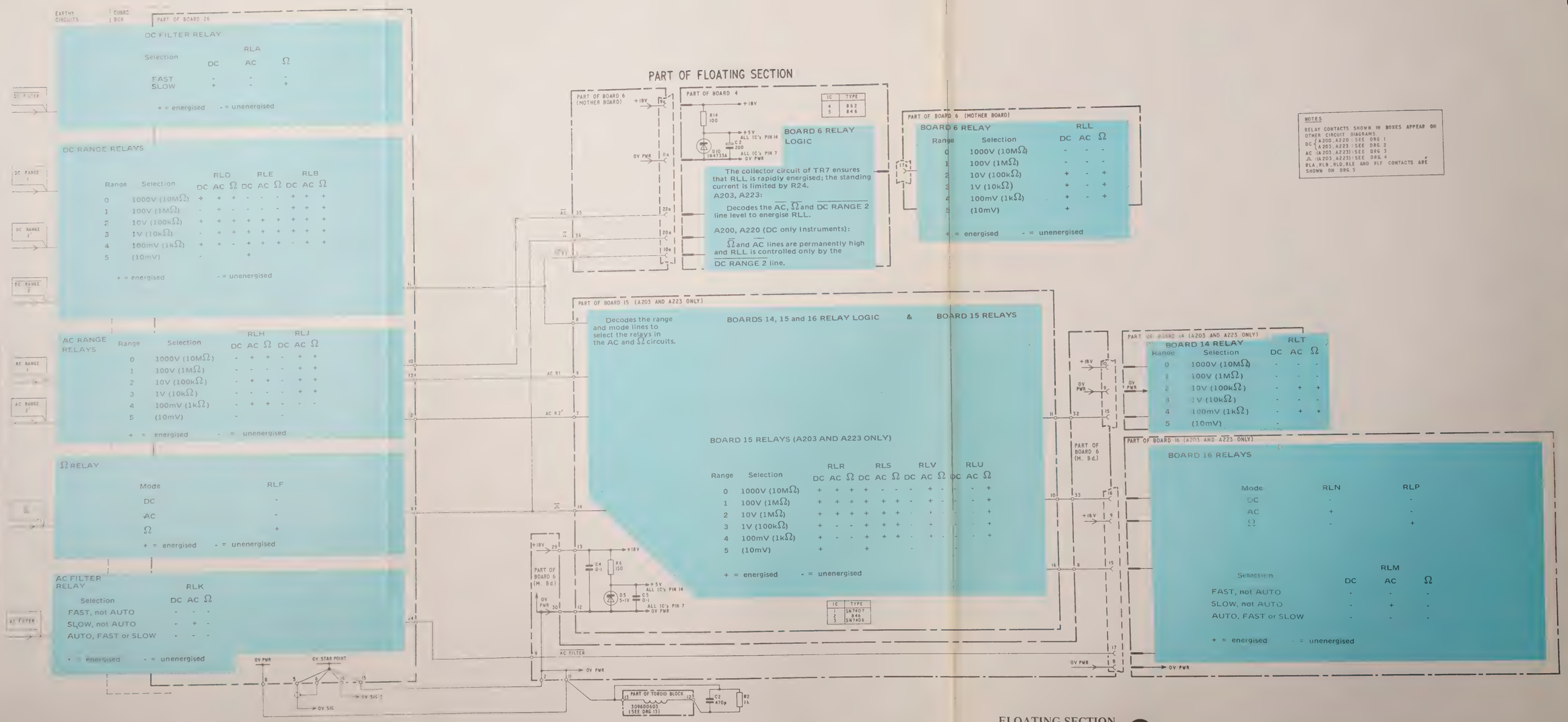

Fig. 7.42 Pcb 2 A220, A223




INPUT AMPLIFIER (10μV) CIRCUIT 7

JR/A200/2

7.7.4


PART OF FLOATING SECTION
DC FILTER RELAY
RLA
Selection DC AC Ω
FAST - - -
SLOW + - +
+ = energised - = unenergised
DC RANGE RELAYS
Range Selection RLD DC AC Ω RLE DC AC Ω RLB DC AC Ω
0 1000V (10MΩ) + + + - - - + + +
1 100V (1MΩ) - + - - - - + + +
2 10V (100kΩ) + + + + + + + + +
3 1V (10kΩ) - + + + + + + + +
4 100mV (1kΩ) + + - + + + - + +
5 (10mV) - + +
+ = energised - = unenergised
AC RANGE RELAYS
Range Selection RLH DC AC Ω RLJ DC AC Ω
0 1000V (10MΩ) - + + - + +
1 100V (1MΩ) - - - - + +
2 10V (100kΩ) - + + - + +
3 1V (10kΩ) - - - - + +
4 100mV (1kΩ) - + + - - -
5 (10mV) - -
+ = energised - = unenergised
Ω RELAY
Mode RLF
DC -
AC -
Ω +
+ = energised - = unenergised
AC FILTER RELAY
Selection RLK DC AC Ω
FAST, not AUTO - - -
SLOW, not AUTO - + -
AUTO, FAST or SLOW - - -
+ = energised - = unenergised
BOARD 6 RELAY LOGIC
The collector circuit of TR7 ensures that RLL is rapidly energised; the standing current is limited by R24.
A203, A223:
Decodes the AC, Ω and DC RANGE 2 line level to energise RLL.
A200, A220 (DC only instruments):
Ω and AC lines are permanently high and RLL is controlled only by the DC RANGE 2 line.
BOARD 6 RELAY
Range Selection RLL DC AC Ω
0 1000V (10MΩ) - - -
1 100V (1MΩ) - - -
2 10V (100kΩ) + - +
3 1V (10kΩ) + - +
4 100mV (1kΩ) + - +
5 (10mV) +
+ = energised - = unenergised
BOARDS 14, 15 and 16 RELAY LOGIC & BOARD 15 RELAYS
Decodes the range and mode lines to select the relays in the AC and Ω circuits.
BOARD 15 RELAYS (A203 AND A223 ONLY)
Range Selection RLR DC AC Ω RLS DC AC Ω RLV DC AC Ω RLU DC AC Ω
0 1000V (10MΩ) + + + + - - - + - - - +
1 100V (1MΩ) + + + + + + - + - - - +
2 10V (1MΩ) + + + + + + - + - - - +
3 1V (100kΩ) + - - + + + - + - - - +
4 100mV (1kΩ) + - - + + + - + - - - +
5 (10mV) + + - - -
+ = energised - = unenergised
BOARD 14 RELAY
Range Selection RLT DC AC Ω
0 1000V (10MΩ) - - -
1 100V (1MΩ) - - -
2 10V (100kΩ) - + +
3 1V (10kΩ) - - -
4 100mV (1kΩ) - + +
5 (10mV) -
BOARD 16 RELAYS
Mode RLN RLP
DC - -
AC + -
Ω - +
Selection RLM DC AC Ω
FAST, not AUTO - - -
SLOW, not AUTO - + -
AUTO, FAST or SLOW - - -
+ = energised - = unenergised
NOTES
RELAY CONTACTS SHOWN IN BOXES APPEAR ON OTHER CIRCUIT DIAGRAMS.
DC (A200, A220 : SEE DRG 1
(A203, A223 : SEE DRG 2
AC (A203, A223) : SEE DRG 3
Ω (A203, A223) : SEE DRG 4
RLA, RLB, RLD, RLE AND RLF CONTACTS ARE SHOWN ON DRG 5
PART OF BOARD 26
PART OF BOARD 6 (MOTHER BOARD)
PART OF BOARD 4
PART OF BOARD 15 (A203 AND A223 ONLY)
PART OF BOARD 14 (A203 AND A223 ONLY)
PART OF BOARD 16 (A203 AND A223 ONLY)
PART OF BOARD 6 (M. Bd.)
PART OF TOROID BLOCK
309600603 (SEE DRG 5)
+18V
+5V
0V PWR
0V STAR POINT
0V SIG
AC FILTER
DC FILTER
DC RANGE 1
DC RANGE 2
AC RANGE 1
AC RANGE 2
Ω
EARTHY CIRCUITS
GUARD
BOX

FLOATING SECTION
RELAYS
DESCRIPTION

8

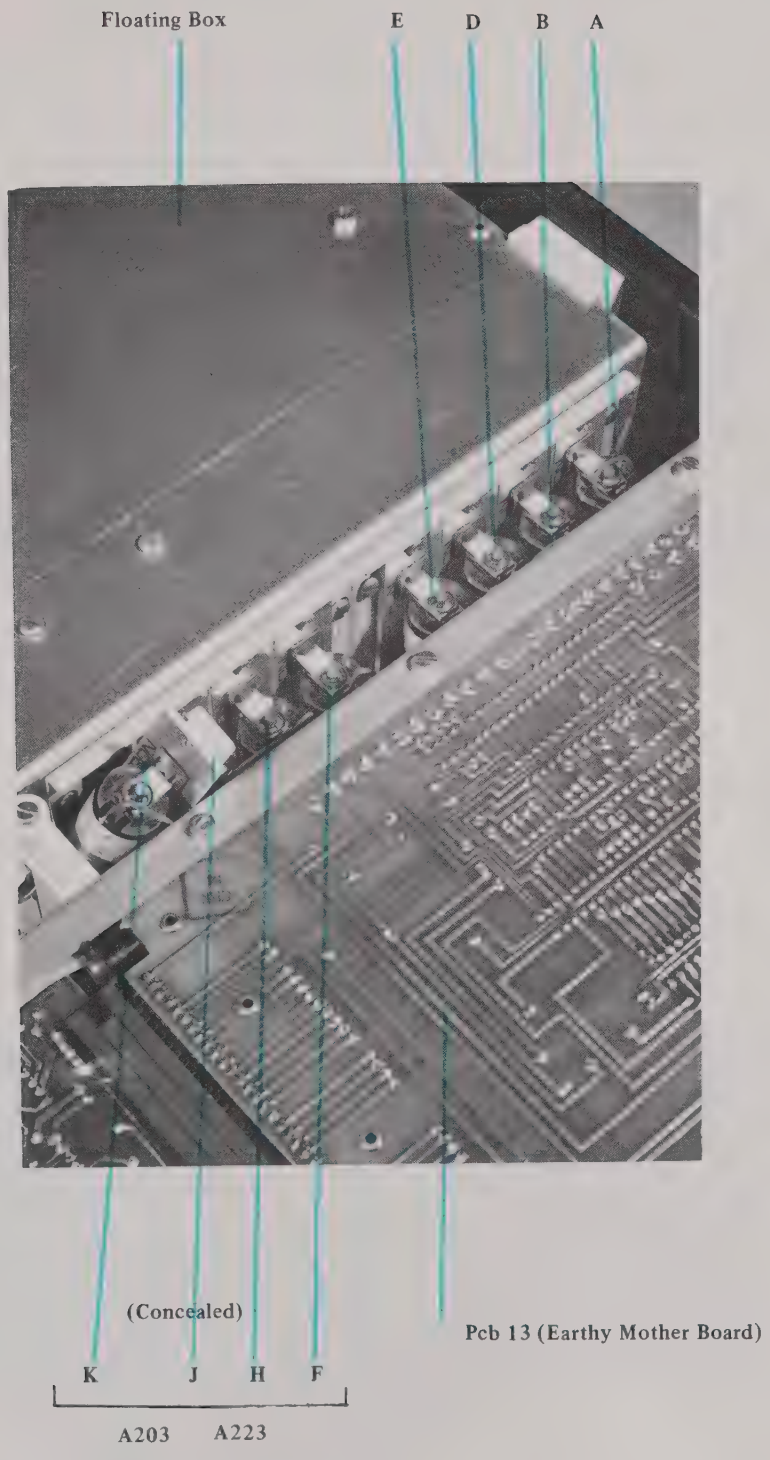



Fig. 7.44 Reed Relay Coil Removal. Underside View.

Fig. 7.44 Shows Relay Coil K and housing unscrewed from the Floating Box.

To remove the coil from the contact housing, remove both spire fasteners and the core rod.

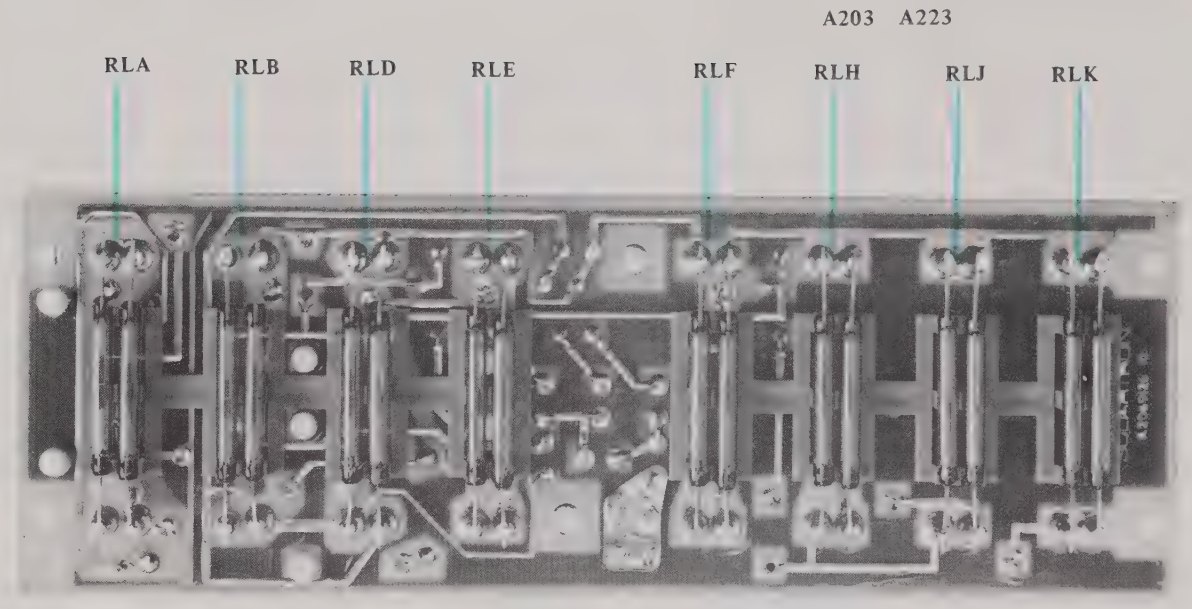



Fig. 7.45 Pcb 26 Copper Side, and Reed Relay Contacts

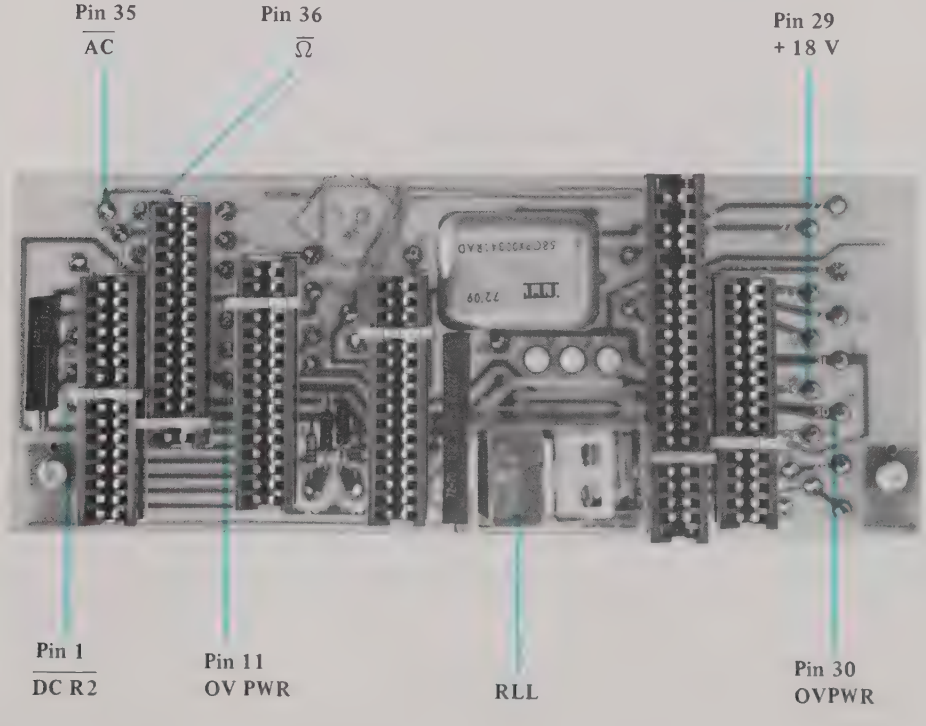



Fig. 7.46 Pcb 6 Mother Board

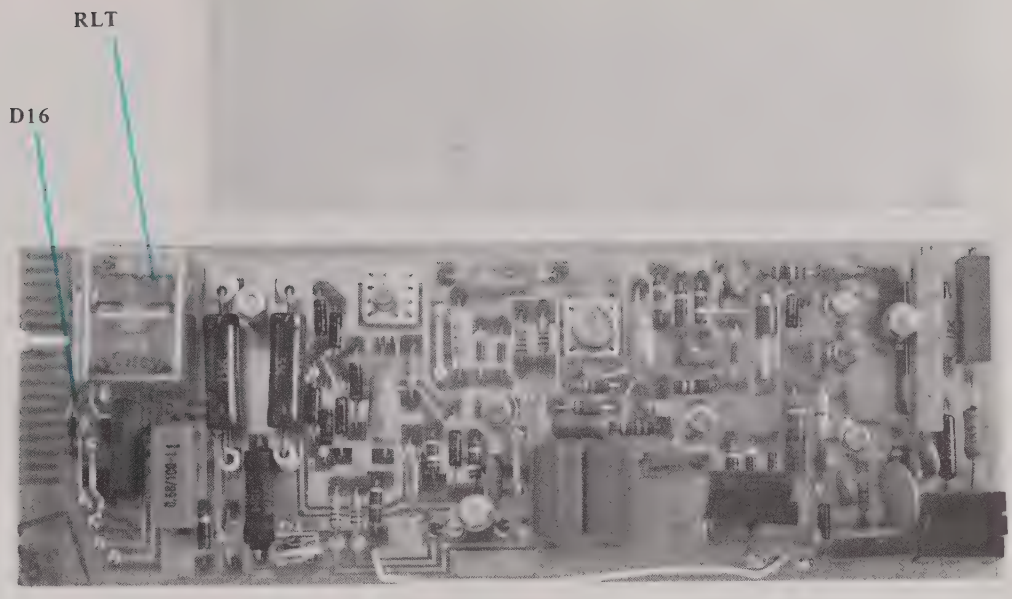



Fig. 7.47 Pcb 14 RLT

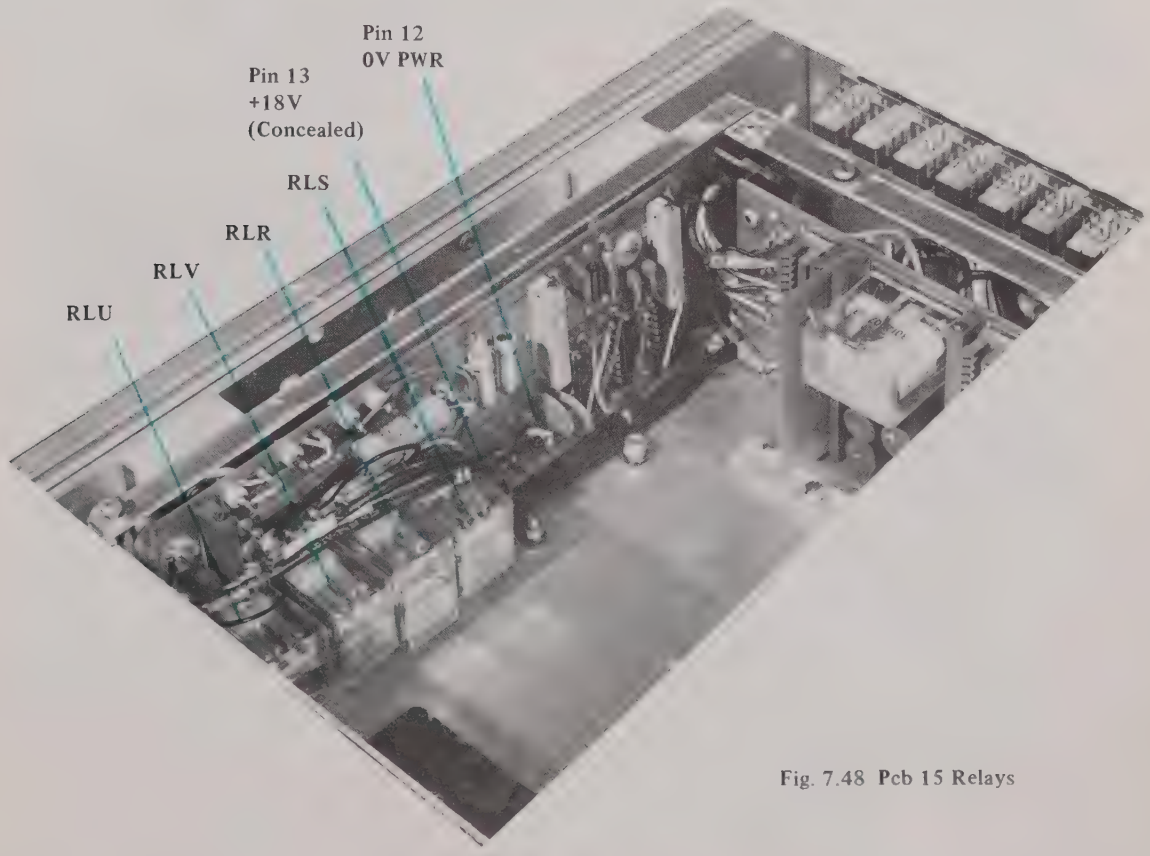



Fig. 7.48 Pcb 15 Relays

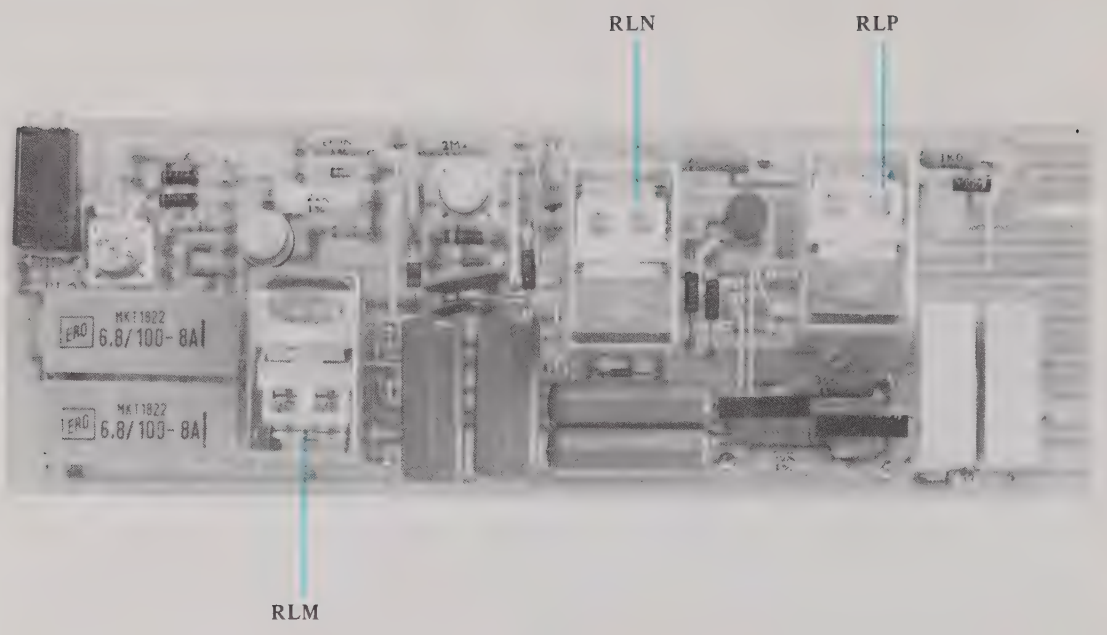



Fig. 7.49 Pcb 16 Relays

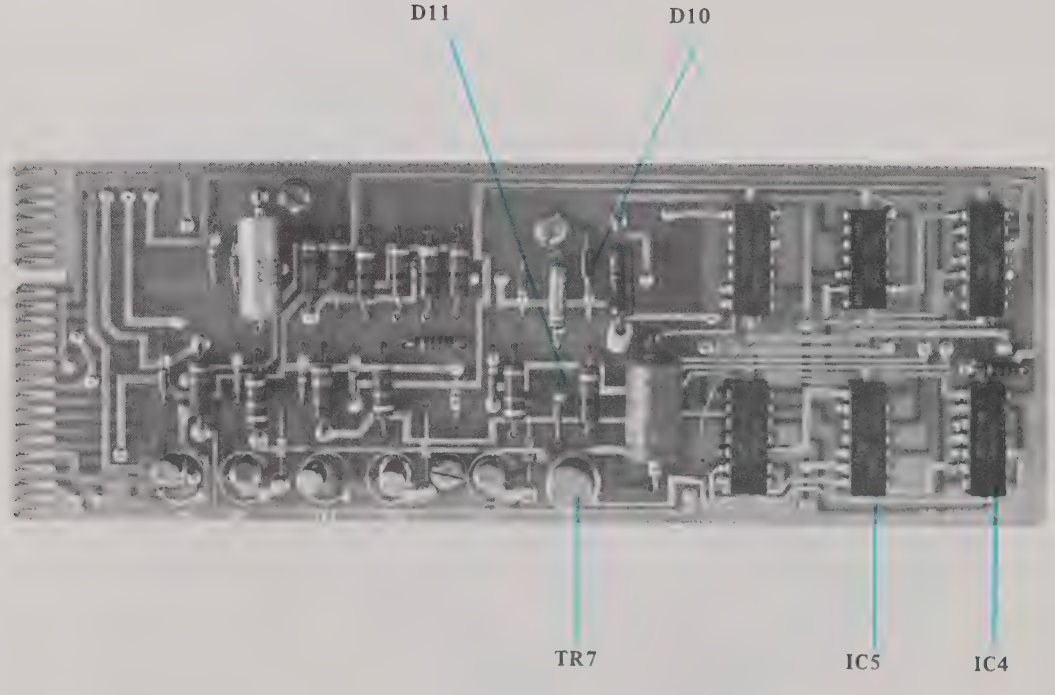
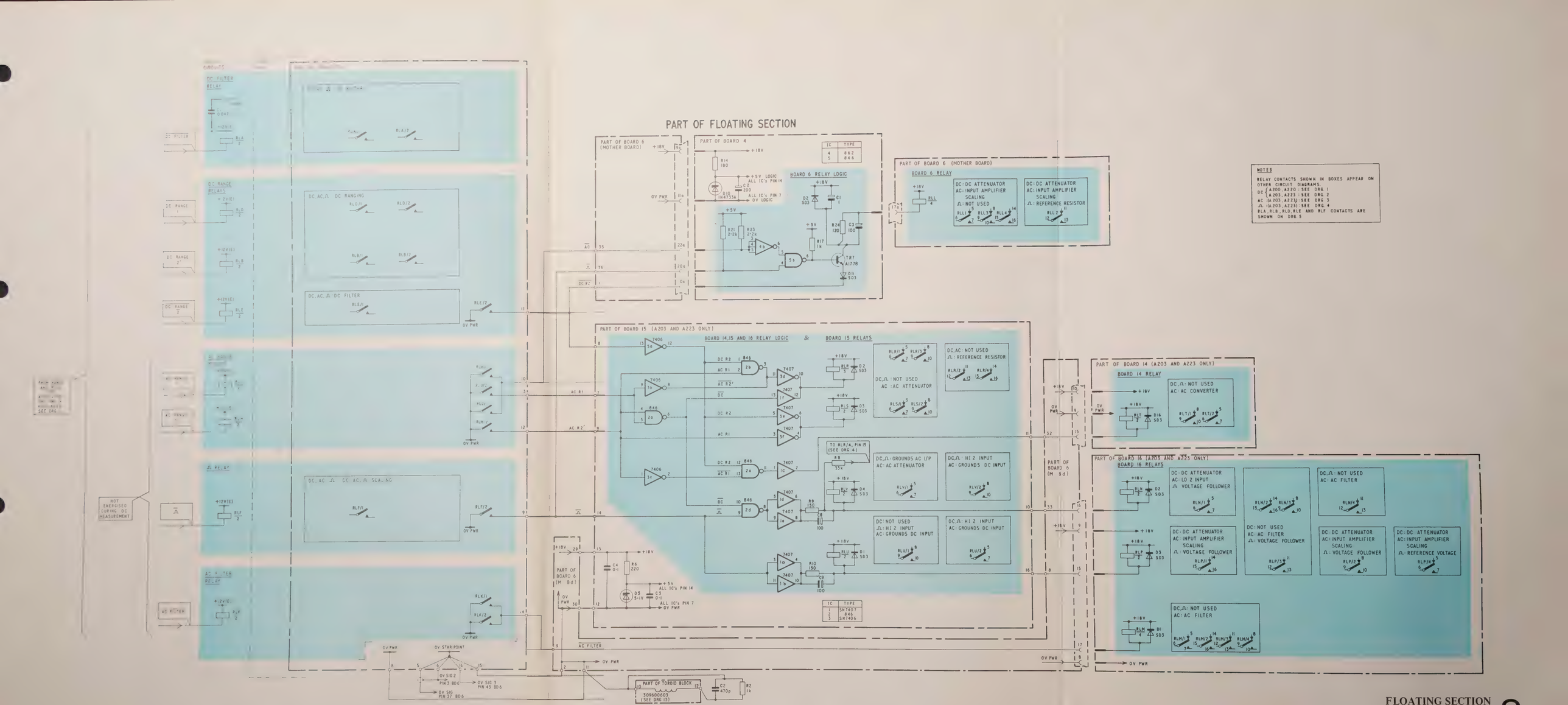
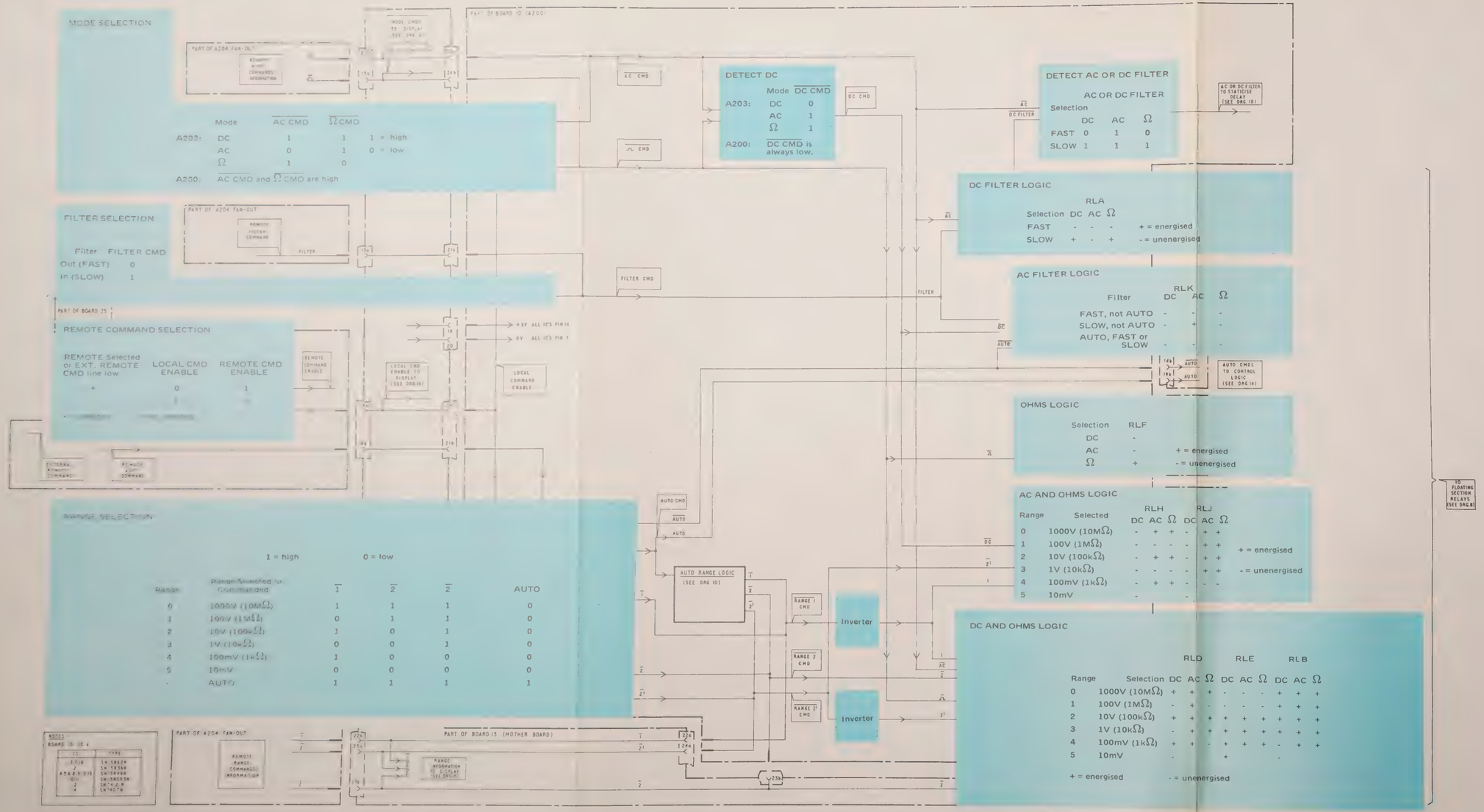



Fig.7.50 Pcb 4 RLL Drive


PART OF FLOATING SECTION
DC FILTER RELAY
DC RANGE RELAYS
DC RANGE 1
DC RANGE 2
DC RANGE 3
DC, AC, Ω : DC RANGING
DC, AC, Ω : DC FILTER
Ω RELAY
DC, AC, Ω : DC, AC, Ω SCALING
AC FILTER RELAY
AC FILTER
NOT ENERGISED DURING DC MEASUREMENT
PART OF BOARD 6 (MOTHER BOARD)
PART OF BOARD 4
BOARD 6 RELAY LOGIC
BOARD 6 RELAY
DC : DC ATTENUATOR AC : INPUT AMPLIFIER SCALING Ω : NOT USED
DC : DC ATTENUATOR AC : INPUT AMPLIFIER SCALING Ω : REFERENCE RESISTOR
PART OF BOARD 15 (A203 AND A223 ONLY)
BOARD 14,15 AND 16 RELAY LOGIC & BOARD 15 RELAYS
DC,Ω : NOT USED AC : AC ATTENUATOR
DC,AC : NOT USED Ω : REFERENCE RESISTOR
DC,Ω : GROUNDS AC I/P AC : AC ATTENUATOR
DC,Ω : HI Z INPUT AC : GROUNDS DC INPUT
DC : NOT USED Ω : HI Z INPUT AC : GROUNDS DC INPUT
DC,Ω : HI Z INPUT AC : GROUNDS DC INPUT
PART OF BOARD 14 (A203 AND A223 ONLY)
BOARD 14 RELAY
DC,Ω : NOT USED AC : AC CONVERTER
PART OF BOARD 16 (A203 AND A223 ONLY)
BOARD 16 RELAYS
DC : DC ATTENUATOR AC : LO Z INPUT Ω : VOLTAGE FOLLOWER
DC,Ω : NOT USED AC : AC FILTER
DC : DC ATTENUATOR AC : INPUT AMPLIFIER SCALING Ω : VOLTAGE FOLLOWER
DC : NOT USED AC : AC FILTER Ω : VOLTAGE FOLLOWER
DC : DC ATTENUATOR AC : INPUT AMPLIFIER SCALING Ω : REFERENCE VOLTAGE
DC,Ω : NOT USED AC : AC FILTER
PART OF BOARD 6 (M Bd)
AC FILTER
PART OF TOROID BLOCK 309600603 (SEE DRG 15)
OV STAR POINT
OV SIG 2 PIN 3 BD6
OV SIG 3 PIN 43 BD6
OV SIG PIN 57 BD6
NOTES
RELAY CONTACTS SHOWN IN BOXES APPEAR ON OTHER CIRCUIT DIAGRAMS.
DC { A200, A220 : SEE DRG 1 A203, A223 : SEE DRG 2
AC (A203, A223) : SEE DRG 3
Ω (A203, A223) : SEE DRG 4
RLA, RLB, RLD, RLE AND RLF CONTACTS ARE SHOWN ON DRG 5

**FLOATING SECTION RELAYS CIRCUIT** 8


MODE SELECTION
Mode AC CMD Ω CMD
A203: DC 1 1
AC 0 1
Ω 1 0
A200: AC CMD and Ω CMD are high
1 = high
0 = low
FILTER SELECTION
Filter FILTER CMD
Out (FAST) 0
In (SLOW) 1
REMOTE COMMAND SELECTION
REMOTE Selected or EXT. REMOTE CMD line low
LOCAL CMD ENABLE
REMOTE CMD ENABLE
RANGE SELECTION
1 = high
0 = low
Range
Range Selected by Command
AUTO
0 1000V (10MΩ) 1 1 1 0
1 100V (1MΩ) 0 1 1 0
2 10V (100kΩ) 1 0 1 0
3 1V (10kΩ) 0 0 1 0
4 100mV (1kΩ) 1 0 0 0
5 10mV 0 0 0 0
AUTO 1 1 1 1
DETECT DC
Mode DC CMD
A203: DC 0
AC 1
Ω 1
A200: DC CMD is always low.
DETECT AC OR DC FILTER
AC OR DC FILTER
Selection DC AC Ω
FAST 0 1 0
SLOW 1 1 1
DC FILTER LOGIC
RLA
Selection DC AC Ω
FAST - - -
SLOW + - +
+ = energised
- = unenergised
AC FILTER LOGIC
RLK
Filter DC AC Ω
FAST, not AUTO - - -
SLOW, not AUTO - + -
AUTO, FAST or SLOW - - -
OHMS LOGIC
Selection RLF
DC -
AC -
Ω +
+ = energised
- = unenergised
AC AND OHMS LOGIC
RLH RLJ
Range Selected DC AC Ω DC AC Ω
0 1000V (10MΩ) - + + - + +
1 100V (1MΩ) - - - - + +
2 10V (100kΩ) - + + - + +
3 1V (10kΩ) - - - - + +
4 100mV (1kΩ) - + + - - -
5 10mV - - -
+ = energised
- = unenergised
DC AND OHMS LOGIC
RLD RLE RLB
Range Selection DC AC Ω DC AC Ω DC AC Ω
0 1000V (10MΩ) + + + - - - + + +
1 100V (1MΩ) - + - - - - + + +
2 10V (100kΩ) + + + + + + + + +
3 1V (10kΩ) - + + + + + + + +
4 100mV (1kΩ) + + - + + + - + +
5 10mV - + - -
+ = energised
- = unenergised
AUTO RANGE LOGIC (SEE DRG 10)
Inverter
Inverter
AC CMD
Ω CMD
DC CMD
FILTER CMD
AUTO CMD
RANGE 1 CMD
RANGE 2 CMD
RANGE 2¹ CMD
LOCAL CMD ENABLE TO DISPLAY (SEE DRG 18)
LOCAL COMMAND ENABLE
REMOTE COMMAND ENABLE
AUTO CMDS TO CONTROL LOGIC (SEE DRG 14)
AC OR DC FILTER TO STATICISE DELAY (SEE DRG 10)
TO FLOATING SECTION RELAYS (SEE DRG 8)
PART OF A204 FAN-OUT
PART OF BOARD 25
PART OF BOARD 10 (A200)
PART OF BOARD 13 (MOTHER BOARD)
REMOTE RANGE COMMANDS INFORMATION
RANGE INFORMATION TO DISPLAY (SEE DRG 18)
NOTES -
BOARD IS 10 x

# RANGE AND MODE LOGIC (A200 AND A203) DESCRIPTION 9

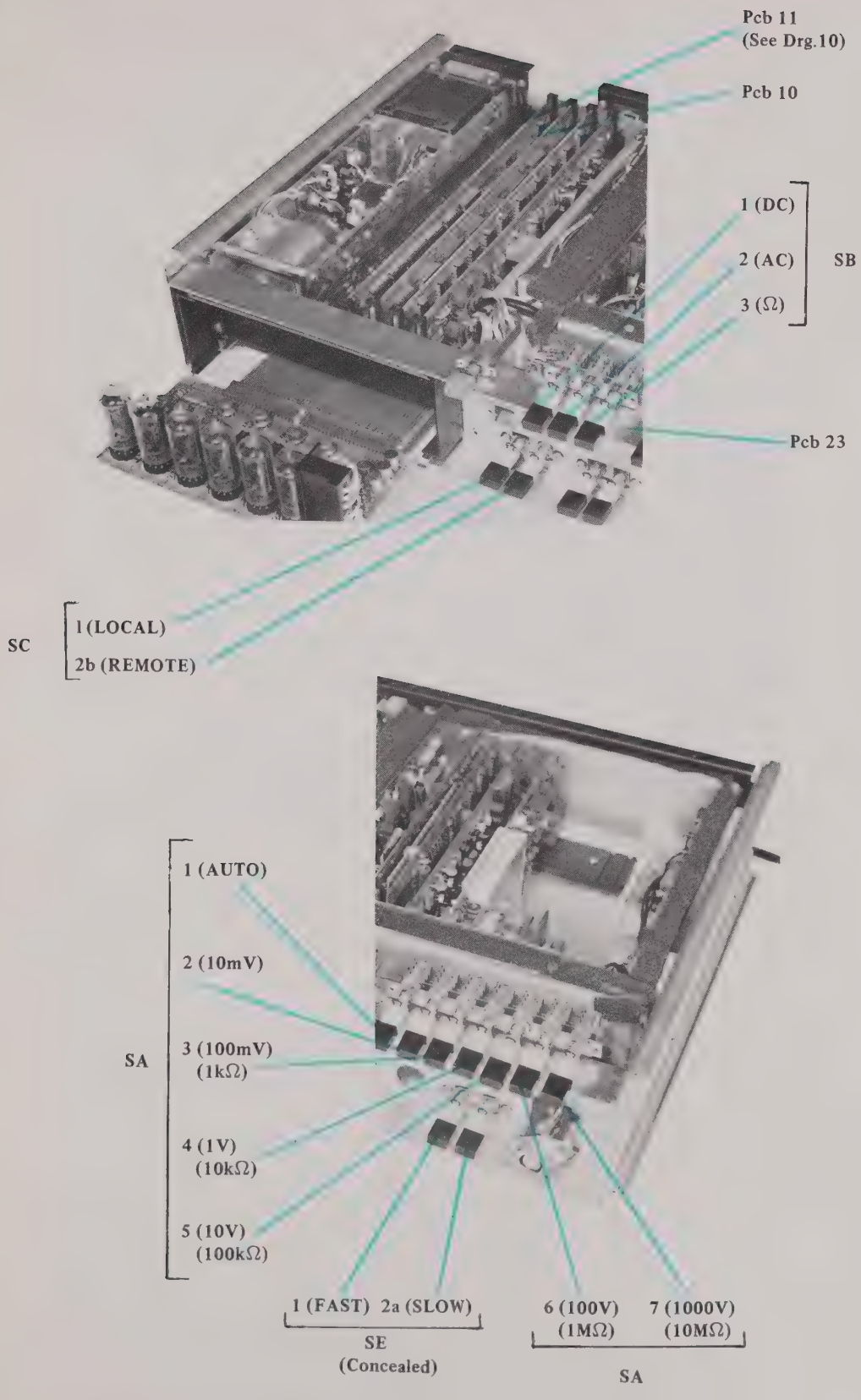



Fig. 7.51 Pcb 10 and Switch Location

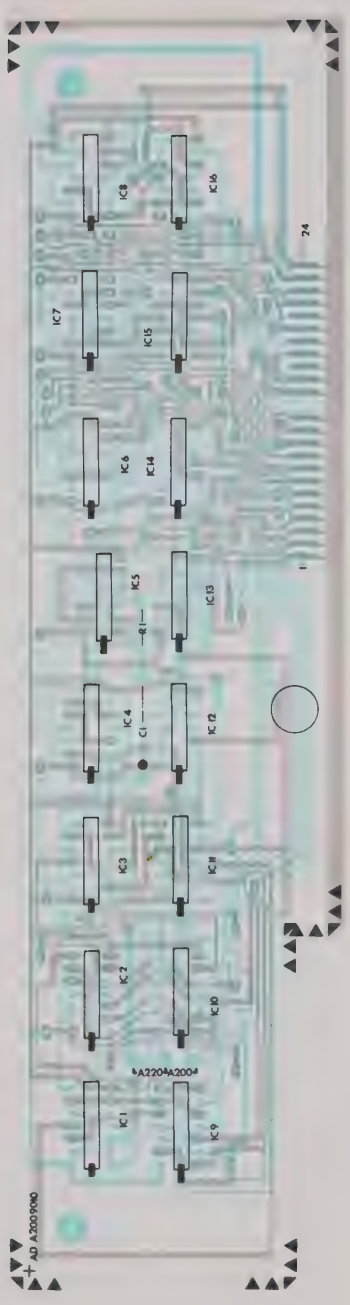



Fig. 7.52 Pcb 10 A200, A203

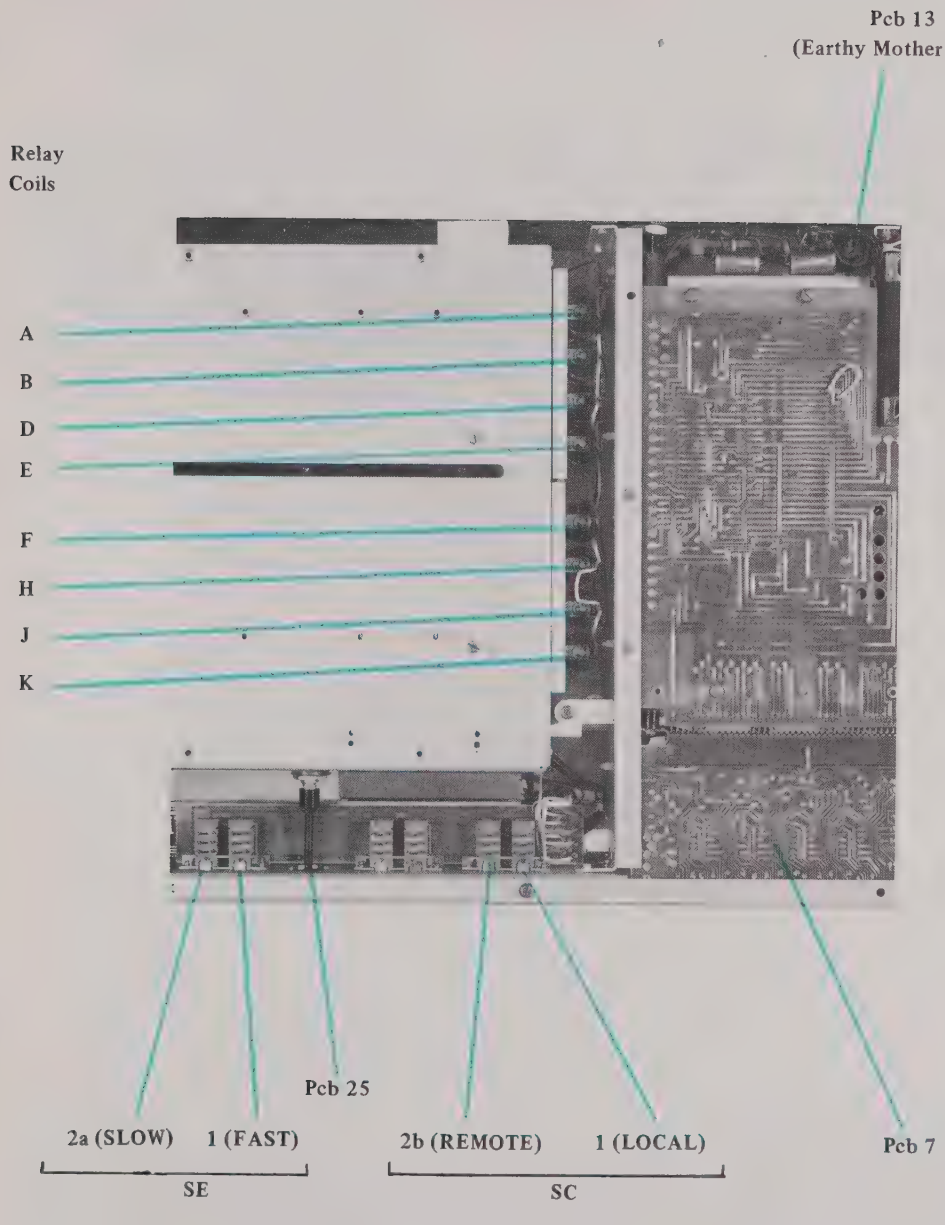



Fig. 7.54 Underside View
(Relay F, H, J, K, on A203)

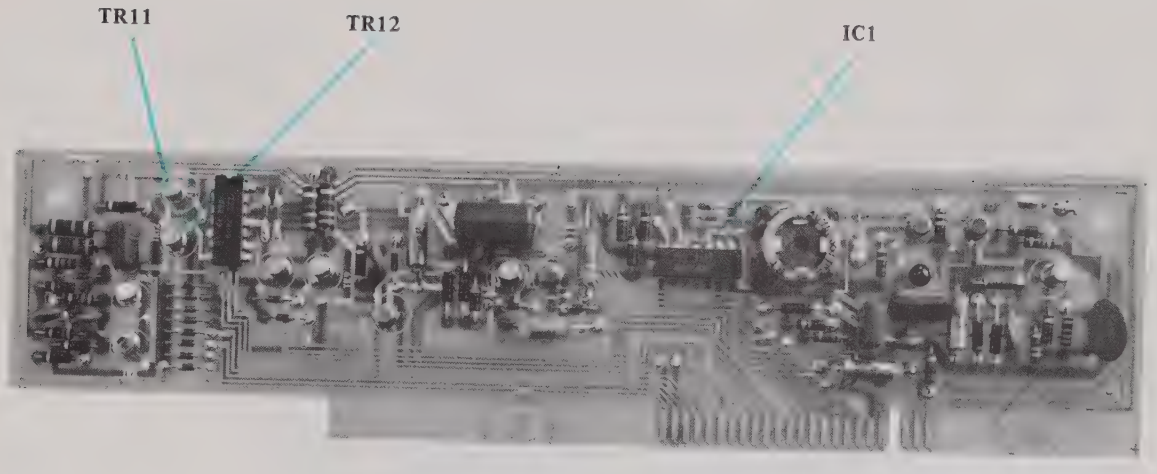



Fig. 7.55 Pcb 8 RLB and RLE Drive

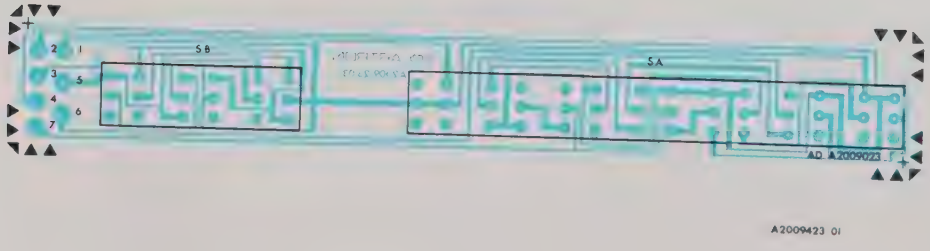
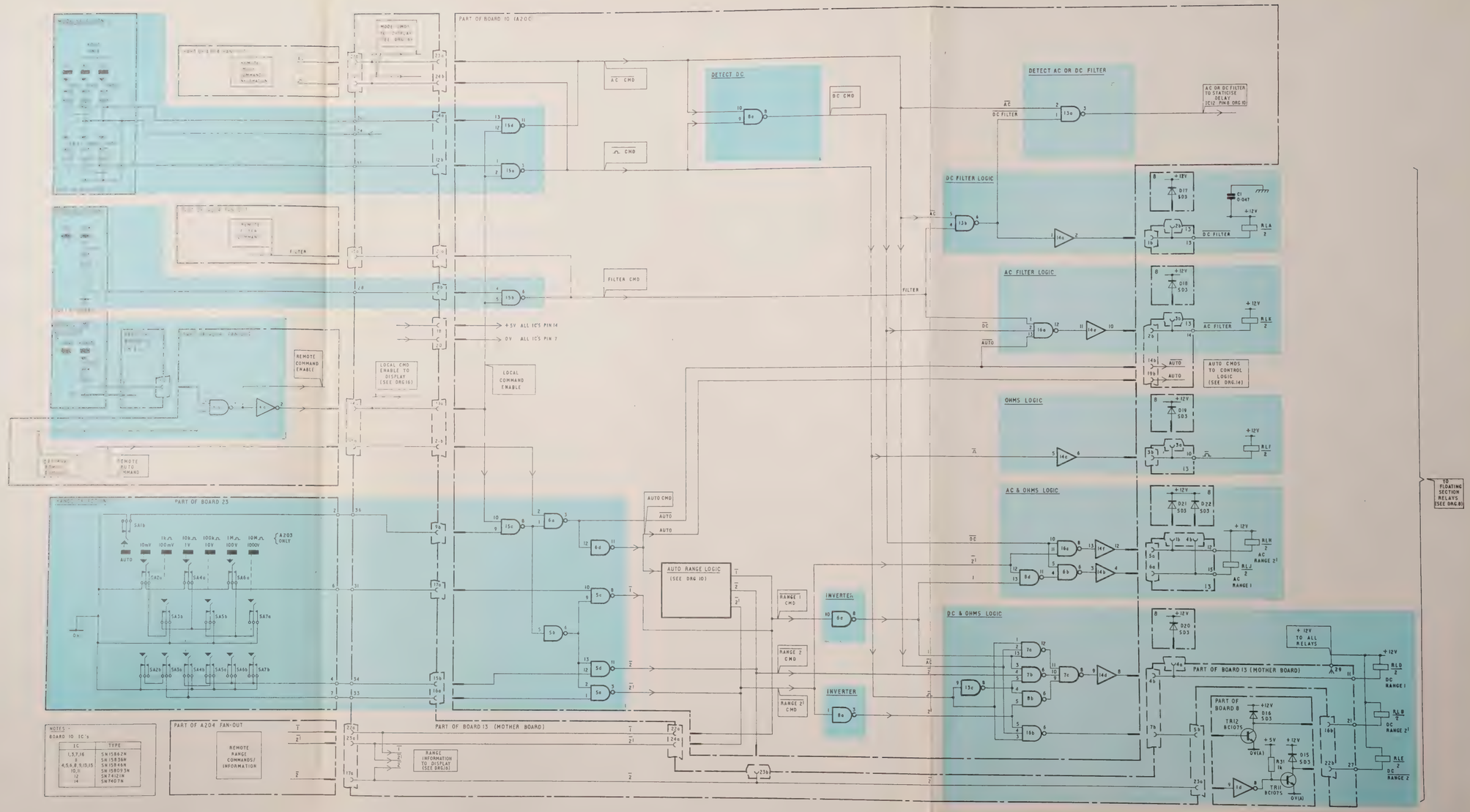


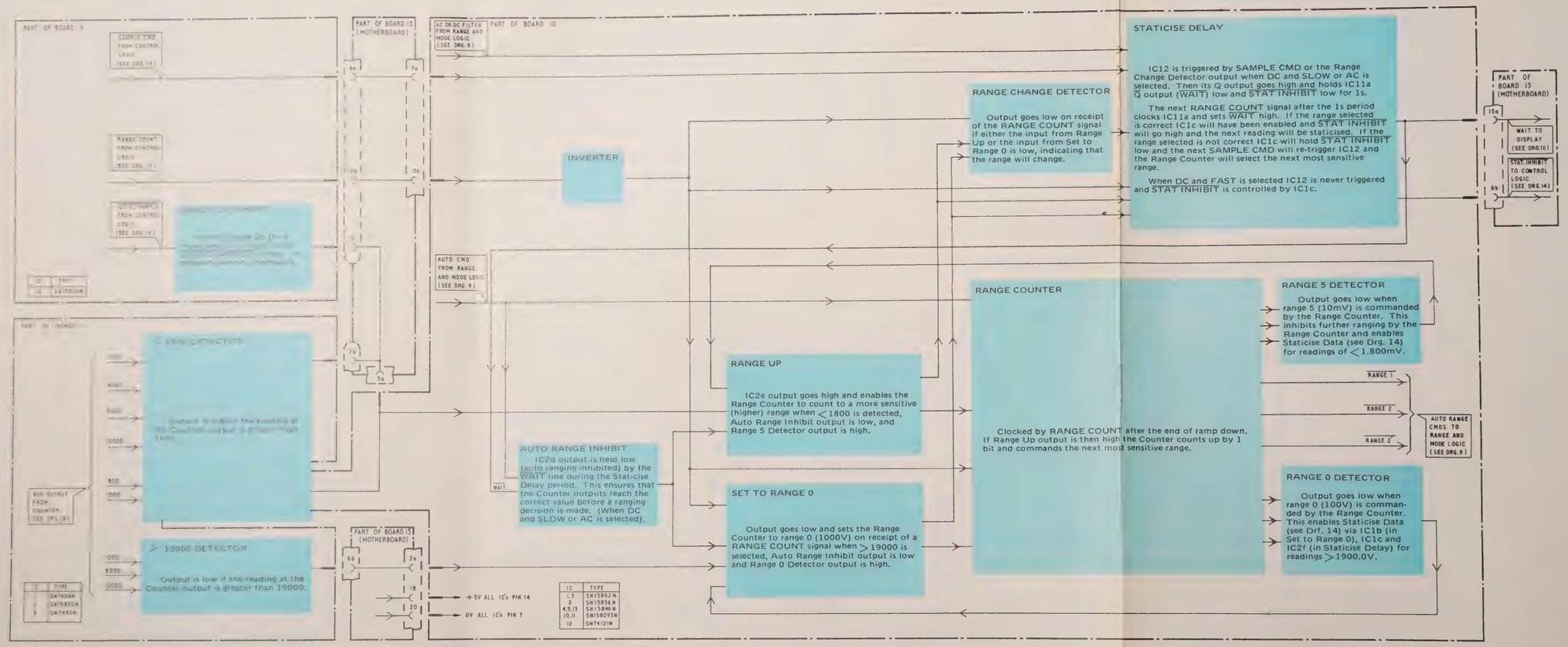

Fig. 7.56 Pcb 23




RANGE AND MODE LOGIC (A200 AND A203) CIRCUIT 9

JR/A200/2

7.9.6


PART OF BOARD 9
SAMPLE CMD FROM CONTROL LOGIC (SEE DRG 14)
RANGE COUNT FROM CONTROL LOGIC (SEE DRG 14)
PART OF BOARD 13 (MOTHERBOARD)
AC OR DC FILTER FROM RANGE AND MODE LOGIC (SEE DRG. 9)
PART OF BOARD 10
INVERTER
AUTO CMD FROM RANGE AND MODE LOGIC (SEE DRG 9)
< 1800 DETECTOR
> 19000 DETECTOR
Output is low if the reading at the Counter output is greater than 19000.
AUTO RANGE INHIBIT
IC2d output is held low (auto ranging inhibited) by the WAIT line during the Staticise Delay period. This ensures that the Counter outputs reach the correct value before a ranging decision is made. (When DC and SLOW or AC is selected).
RANGE UP
IC2e output goes high and enables the Range Counter to count to a more sensitive (higher) range when < 1800 is detected, Auto Range Inhibit output is low, and Range 5 Detector output is high.
SET TO RANGE 0
Output goes low and sets the Range Counter to range 0 (1000V) on receipt of a RANGE COUNT signal when > 19000 is selected, Auto Range Inhibit output is low and Range 0 Detector output is high.
RANGE CHANGE DETECTOR
Output goes low on receipt of the RANGE COUNT signal if either the input from Range Up or the input from Set to Range 0 is low, indicating that the range will change.
STATICISE DELAY
IC12 is triggered by SAMPLE CMD or the Range Change Detector output when DC and SLOW or AC is selected. Then its Q output goes high and holds IC11a Q output (WAIT) low and STAT INHIBIT low for 1s.
The next RANGE COUNT signal after the 1s period clocks IC11a and sets WAIT high. If the range selected is correct IC1c will have been enabled and STAT INHIBIT will go high and the next reading will be staticised. If the range selected is not correct IC1c will hold STAT INHIBIT low and the next SAMPLE CMD will re-trigger IC12 and the Range Counter will select the next most sensitive range.
When DC and FAST is selected IC12 is never triggered and STAT INHIBIT is controlled by IC1c.
RANGE COUNTER
Clocked by RANGE COUNT after the end of ramp down. If Range Up output is then high the Counter counts up by 1 bit and commands the next most sensitive range.
RANGE 5 DETECTOR
Output goes low when range 5 (10mV) is commanded by the Range Counter. This inhibits further ranging by the Range Counter and enables Staticise Data (see Drg. 14) for readings of < 1.800mV.
RANGE 0 DETECTOR
Output goes low when range 0 (100V) is commanded by the Range Counter. This enables Staticise Data (see Drf. 14) via IC1b (in Set to Range 0), IC1c and IC2f (in Staticise Delay) for readings > 1900.0V.
RANGE 1
RANGE 2
RANGE 2'
AUTO RANGE CMDS TO RANGE AND MODE LOGIC (SEE DRG 9)
PART OF BOARD 13 (MOTHERBOARD)
WAIT TO DISPLAY (SEE DRG 16)
STAT INHIBIT TO CONTROL LOGIC (SEE DRG 14)
+5V ALL IC's PIN 14
0V ALL IC's PIN 7
IC TYPE
1,3 SN15862N
2 SN15836N
4,8,13 SN15846N
10,11 SN15893N
12 SN74121N
IC TYPE
1 SN7408N
2 SN15835N
9 SN7490N

# AUTO RANGE LOGIC DESCRIPTION 10

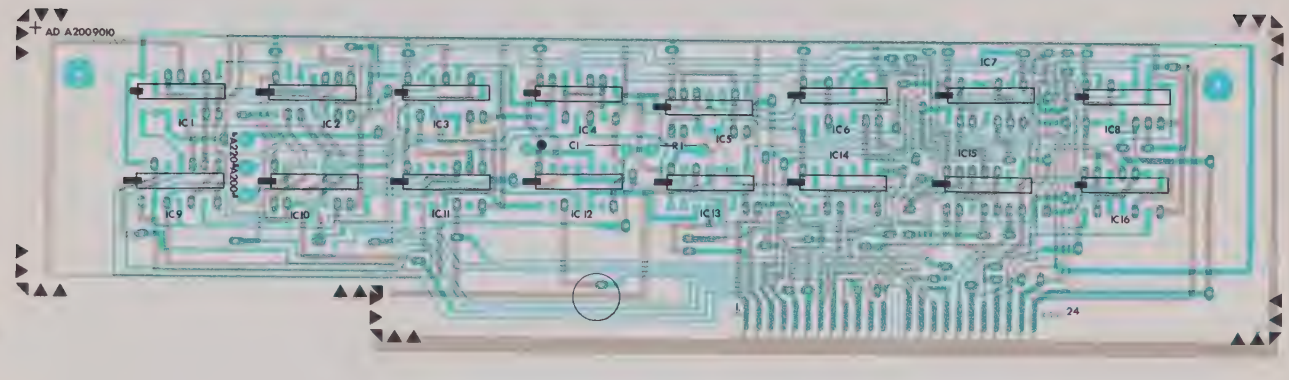



Fig.7.58 Pcb 10 A200, A203

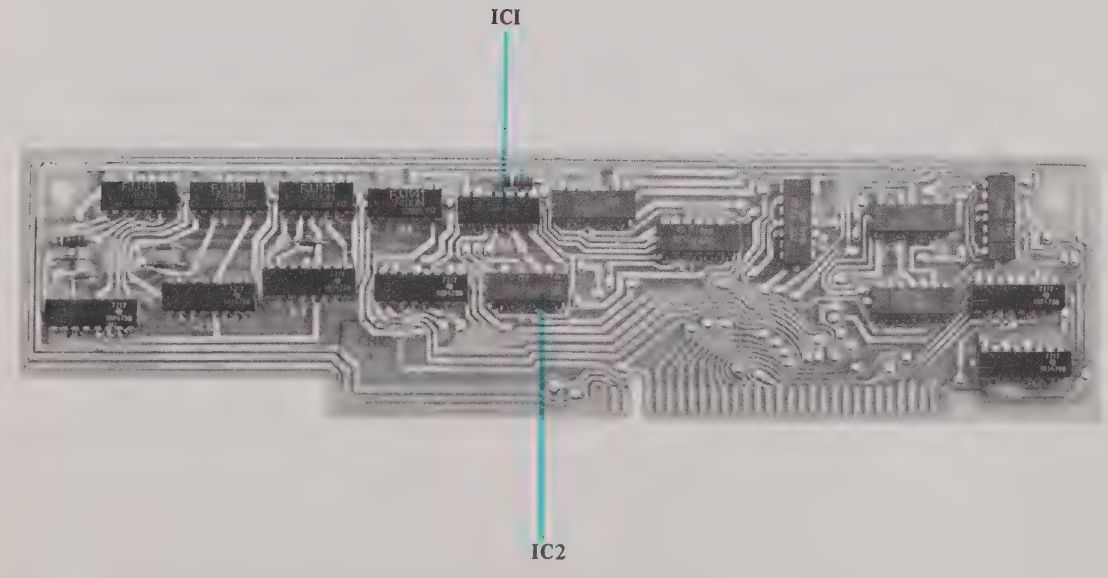
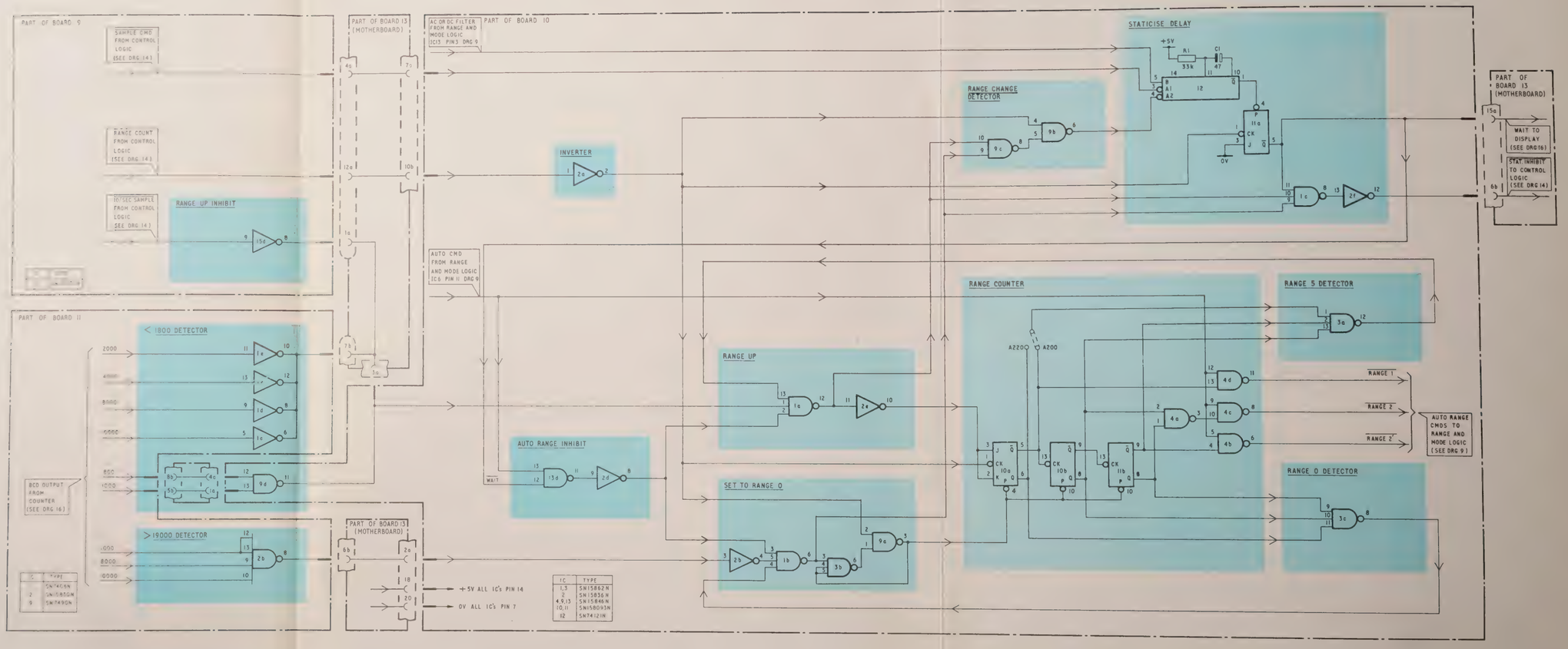


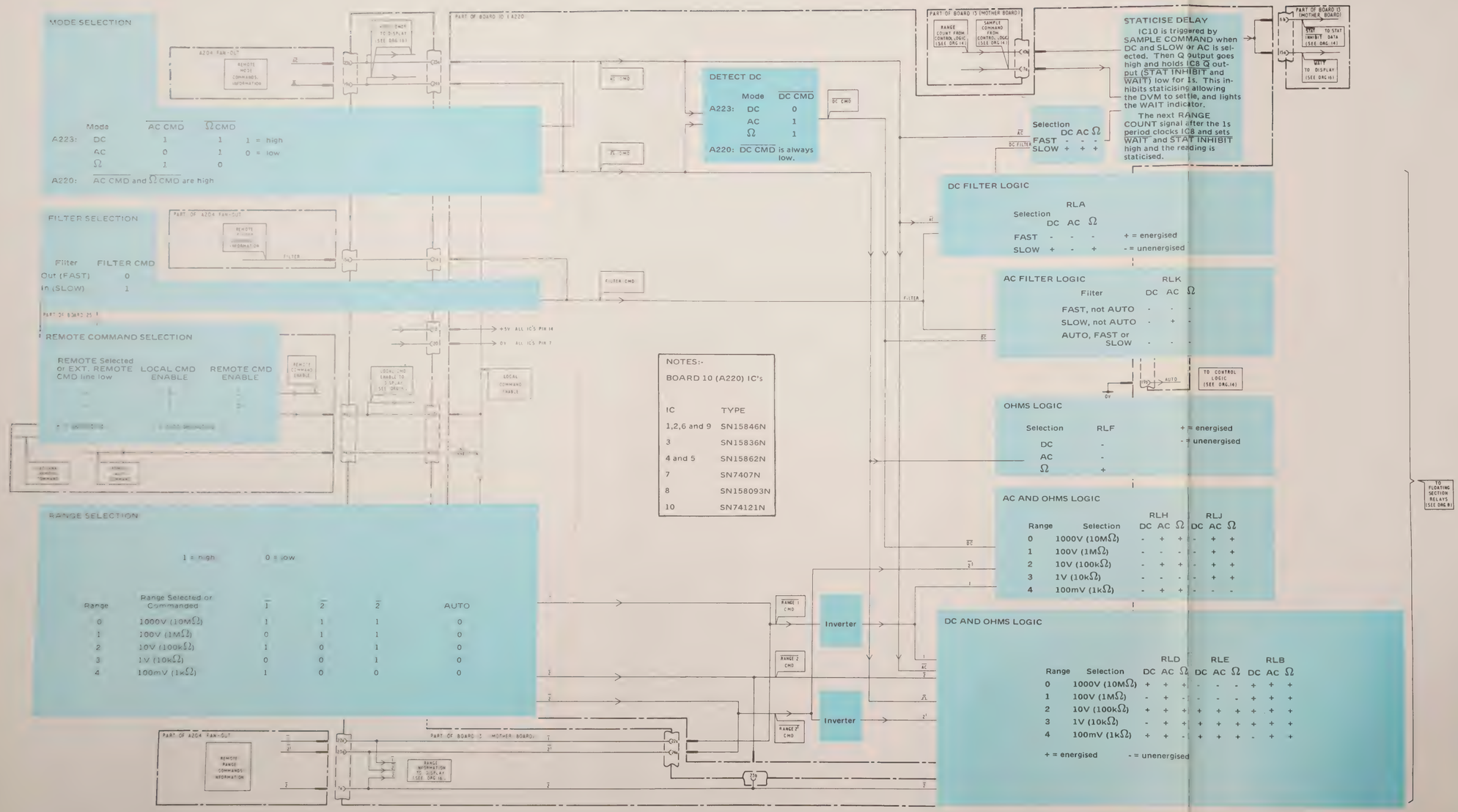

Fig.7.60 Pcb 11, I C's 1 and 2




AUTO RANGE LOGIC CIRCUIT 10

JR/A200/2

7.10.4


MODE SELECTION
Mode AC CMD ΩCMD
A223: DC 1 1 1 = high
AC 0 1 0 = low
Ω 1 0
A220: AC CMD and ΩCMD are high
FILTER SELECTION
Filter FILTER CMD
Out (FAST) 0
In (SLOW) 1
REMOTE COMMAND SELECTION
REMOTE Selected or EXT. REMOTE CMD line low
LOCAL CMD ENABLE
REMOTE CMD ENABLE
RANGE SELECTION
1 = high 0 = low
Range Range Selected or Commanded 1 2 2 AUTO
0 1000V (10MΩ) 1 1 1 0
1 100V (1MΩ) 0 1 1 0
2 10V (100kΩ) 1 0 1 0
3 1V (10kΩ) 0 0 1 0
4 100mV (1kΩ) 1 0 0 0
DETECT DC
Mode DC CMD
A223: DC 0
AC 1
Ω 1
A220: DC CMD is always low.
NOTES:-
BOARD 10 (A220) IC's
IC TYPE
1,2,6 and 9 SN15846N
3 SN15836N
4 and 5 SN15862N
7 SN7407N
8 SN158093N
10 SN74121N
STATICISE DELAY
IC10 is triggered by SAMPLE COMMAND when DC and SLOW or AC is selected. Then Q output goes high and holds IC8 Q output (STAT INHIBIT and WAIT) low for 1s. This inhibits staticising allowing the DVM to settle, and lights the WAIT indicator.
The next RANGE COUNT signal after the 1s period clocks IC8 and sets WAIT and STAT INHIBIT high and the reading is staticised.
Selection DC AC Ω
FAST - - -
SLOW + + +
DC FILTER LOGIC
RLA
Selection DC AC Ω
FAST - - - + = energised
SLOW + - + - = unenergised
AC FILTER LOGIC
RLK
Filter DC AC Ω
FAST, not AUTO - - -
SLOW, not AUTO - + -
AUTO, FAST or SLOW - - -
OHMS LOGIC
Selection RLF
DC -
AC -
Ω +
+ = energised
- = unenergised
AC AND OHMS LOGIC
RLH RLJ
Range Selection DC AC Ω DC AC Ω
0 1000V (10MΩ) - + + - + +
1 100V (1MΩ) - - - - + +
2 10V (100kΩ) - + + - + +
3 1V (10kΩ) - - - - + +
4 100mV (1kΩ) - + + - - -
DC AND OHMS LOGIC
RLD RLE RLB
Range Selection DC AC Ω DC AC Ω DC AC Ω
0 1000V (10MΩ) + + + - - - + + +
1 100V (1MΩ) - + - - - - + + +
2 10V (100kΩ) + + + + + + + + +
3 1V (10kΩ) - + + + + + + + +
4 100mV (1kΩ) + + - + + + - + +
+ = energised - = unenergised
Inverter
Inverter
TO FLOATING SECTION RELAYS (SEE DRG 8)
TO CONTROL LOGIC (SEE DRG 14)
TO STAT INHIBIT DATA (SEE DRG 14)
TO DISPLAY (SEE DRG 16)
RANGE INFORMATION TO DISPLAY (SEE DRG 16)
REMOTE MODE COMMANDS INFORMATION
REMOTE RANGE COMMANDS INFORMATION
REMOTE FILTER INFORMATION
+5V ALL IC'S PIN 14
0V ALL IC'S PIN 7

# RANGE AND MODE LOGIC (A220 AND A223) DESCRIPTION 11

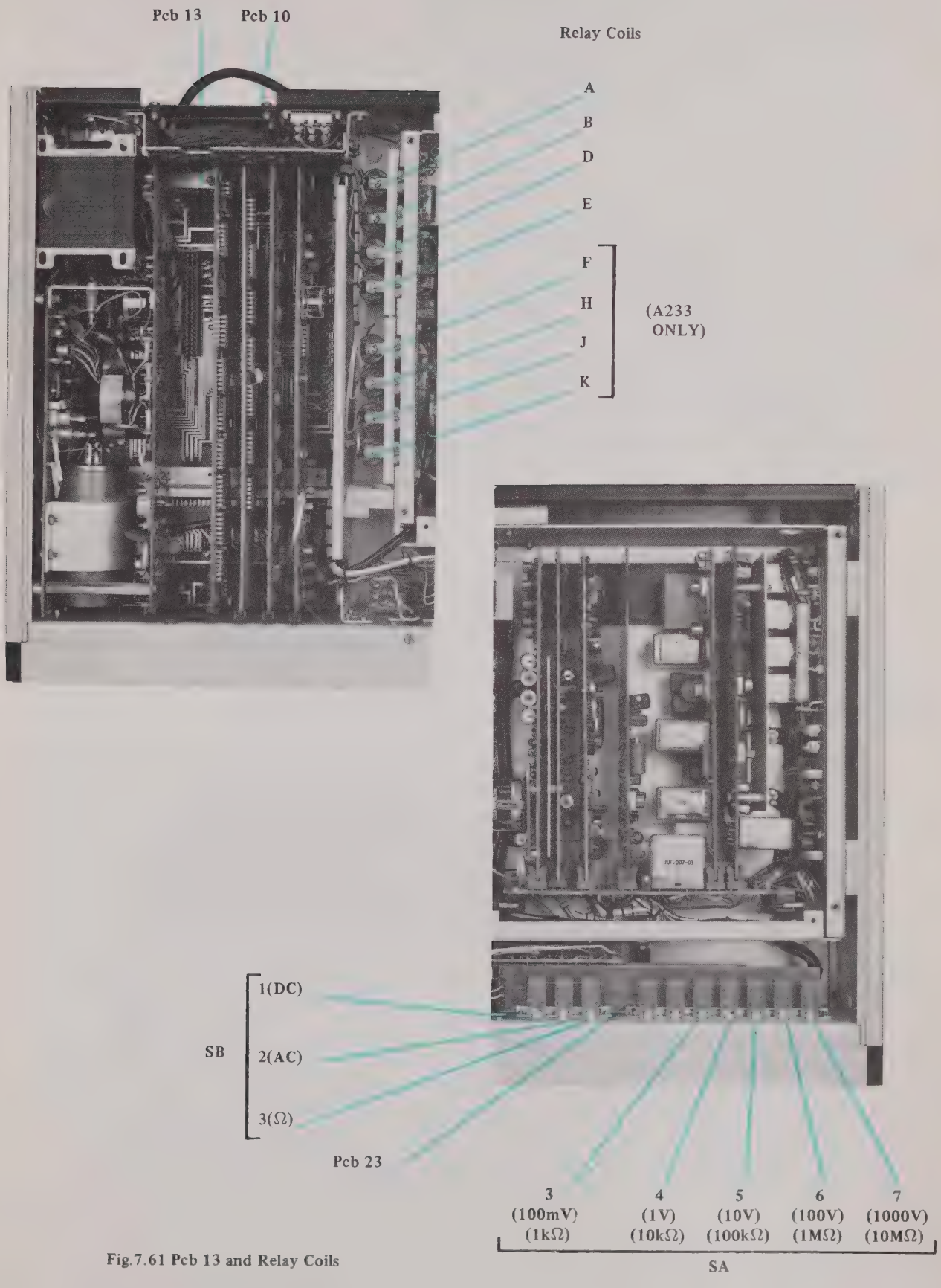



Fig.7.61 Pcb 13 and Relay Coils

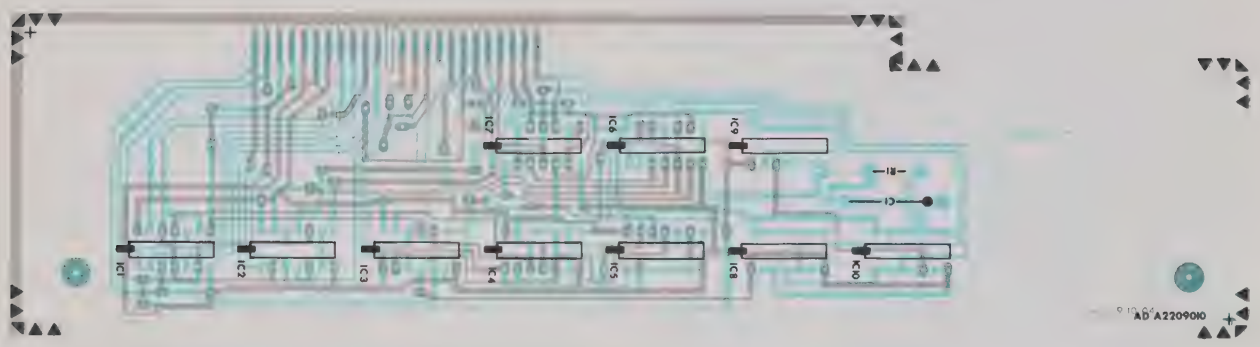



Fig.7.62 Pcb 10 A220, A223

SD

Pcb 25 1 (10/SEC) 2 (MANUAL)

2a (SLOW) 1 (FAST) 2b (REMOTE) 1 (LOCAL)

SE SC

Fig.7.64 Pcb 25, SE and SC

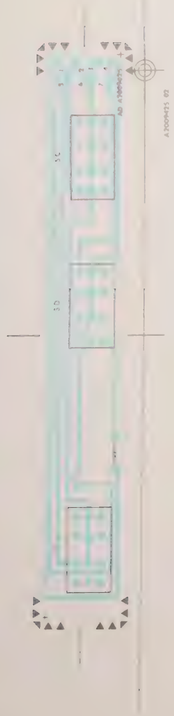
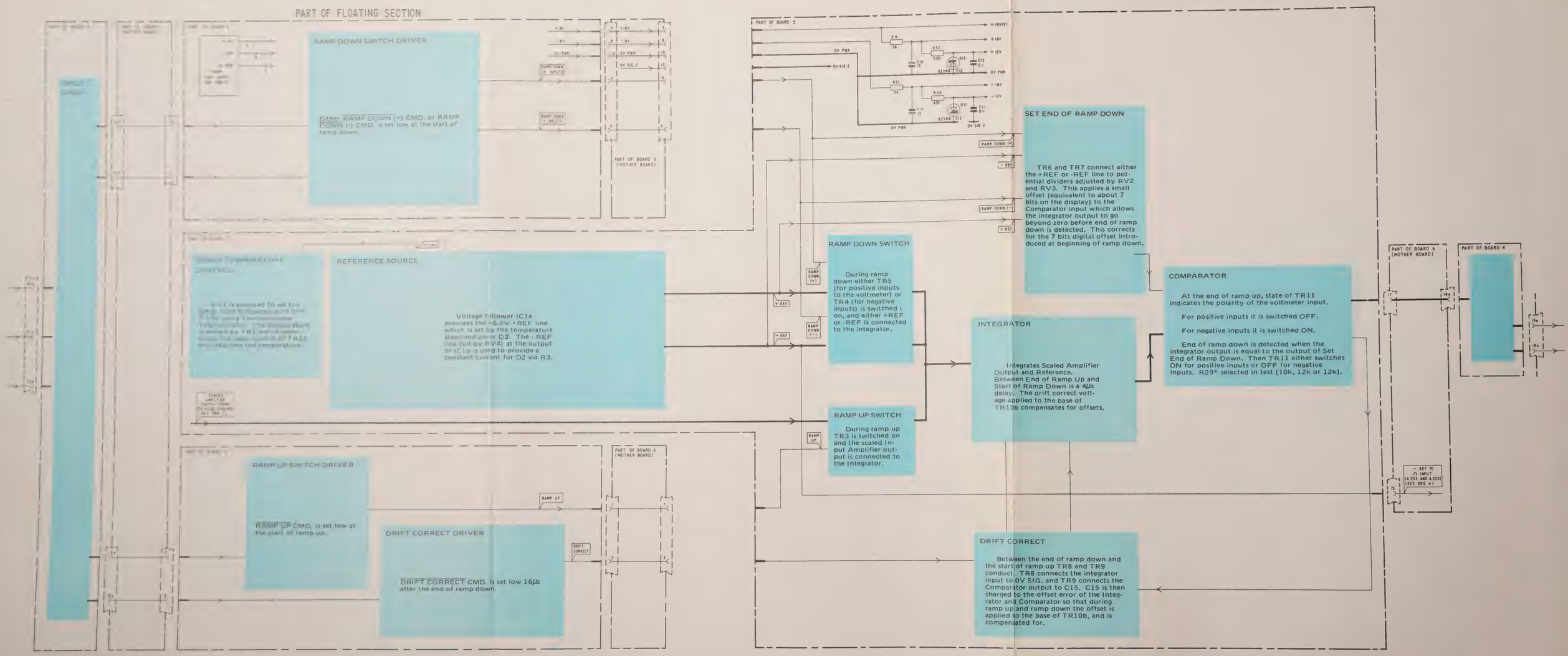


Fig.7.65 Pcb 25

For SD Circuit (10/SEC and MANUAL) see DRG 14 "LOCAL SAMPLE"

# RANGE AND MODE LOGIC (A220 AND A223) CIRCUIT

11


PART OF FLOATING SECTION
RAMP DOWN SWITCH DRIVER
Either RAMP DOWN (+) CMD. or RAMP DOWN (-) CMD. is set low at the start of ramp down.
PART OF BOARD 6 (MOTHER BOARD)
REFERENCE SOURCE
Voltage follower IC1a provides the +6.2V + REF line which is set by the temperature stabilised zener D2. The - REF line (set by RV4) at the output of IC1b is used to provide a constant current for D2 via R3.
RAMP UP SWITCH DRIVER
RAMP UP CMD. is set low at the start of ramp up.
DRIFT CORRECT DRIVER
DRIFT CORRECT CMD. is set low 16µs after the end of ramp down.
PART OF BOARD 3
RAMP DOWN SWITCH
During ramp down either TR5 (for positive inputs to the voltmeter) or TR4 (for negative inputs) is switched on, and either +REF or -REF is connected to the integrator.
RAMP UP SWITCH
During ramp up TR3 is switched on and the scaled Input Amplifier output is connected to the integrator.
SET END OF RAMP DOWN
TR6 and TR7 connect either the +REF or -REF line to potential dividers adjusted by RV2 and RV3. This applies a small offset (equivalent to about 7 bits on the display) to the Comparator input which allows the integrator output to go beyond zero before end of ramp down is detected. This corrects for the 7 bits digital offset introduced at beginning of ramp down.
INTEGRATOR
Integrates Scaled Amplifier Output and Reference. Between End of Ramp Up and Start of Ramp Down is a 4µs delay. The drift correct voltage applied to the base of TR10b compensates for offsets.
COMPARATOR
At the end of ramp up, state of TR11 indicates the polarity of the voltmeter input.
For positive inputs it is switched OFF.
For negative inputs it is switched ON.
End of ramp down is detected when the integrator output is equal to the output of Set End of Ramp Down. Then TR11 either switches ON for positive inputs or OFF for negative inputs. R29* selected in test (10k, 12k or 12k).
DRIFT CORRECT
Between the end of ramp down and the start of ramp up TR8 and TR9 conduct. TR8 connects the integrator input to 0V SIG. and TR9 connects the Comparator output to C15. C15 is then charged to the offset error of the integrator and Comparator so that during ramp up and ramp down the offset is applied to the base of TR10b, and is compensated for.
PART OF BOARD 4
- REF TO J1 INPUT (A 203 AND A 223) (SEE DRG 4)

INTEGRATOR DESCRIPTION 12

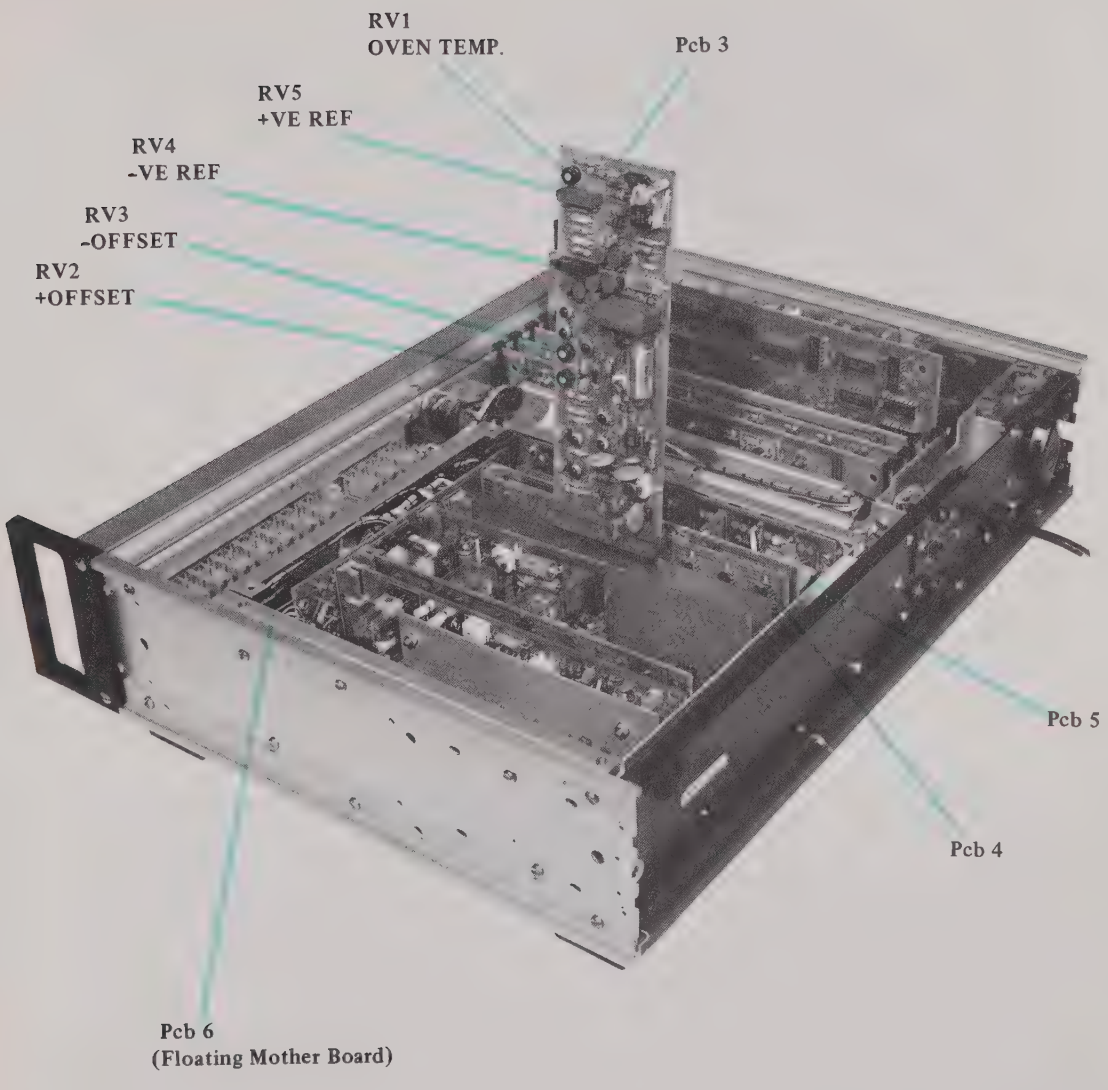



Fig.7.66 Pcb 3 on Extension Board

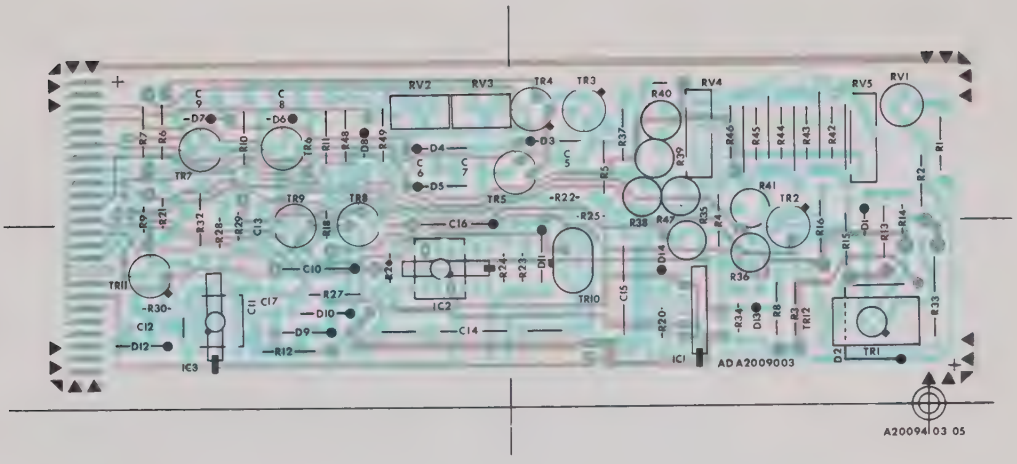



Fig.7.67 Pcb 3

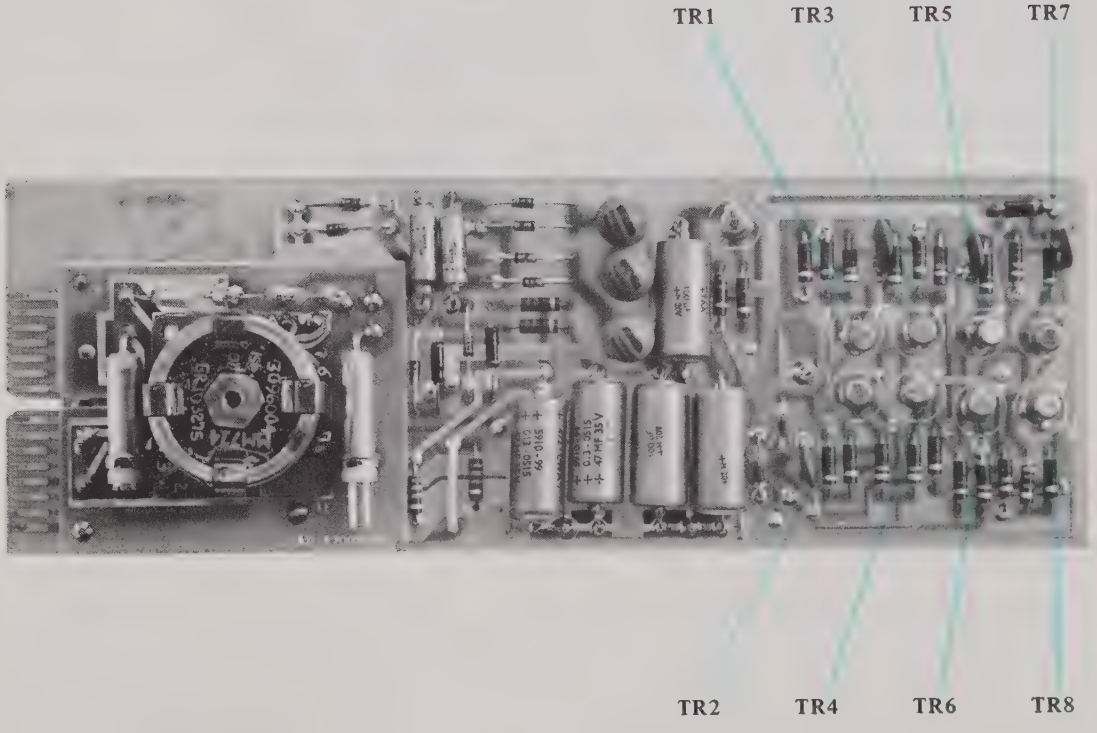
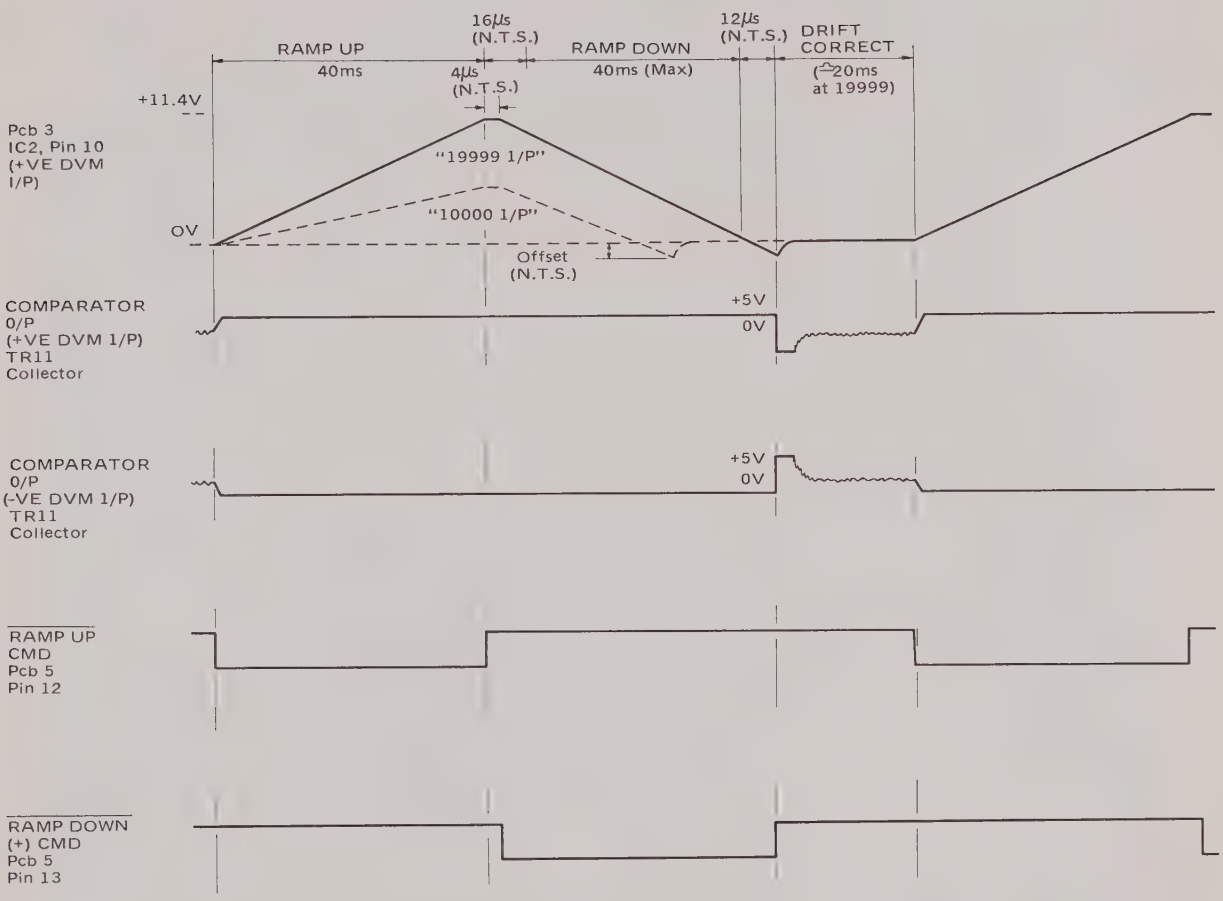


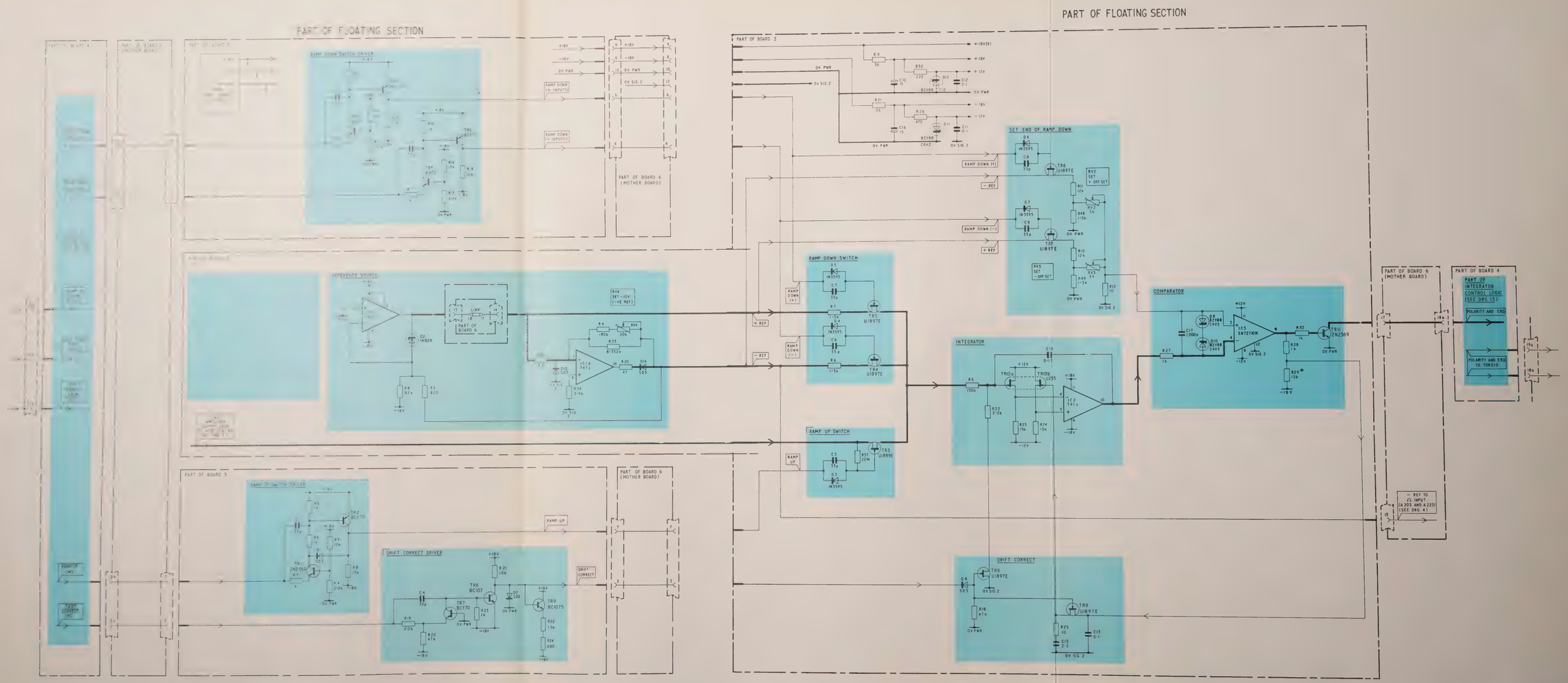

Fig.7.69 Pcb 5, Floating Power Supply and Integrator Switch Drivers.




NOTE: N.T.S. = NOT TO SCALE

Fig.7.70 **INTEGRATOR** Waveforms

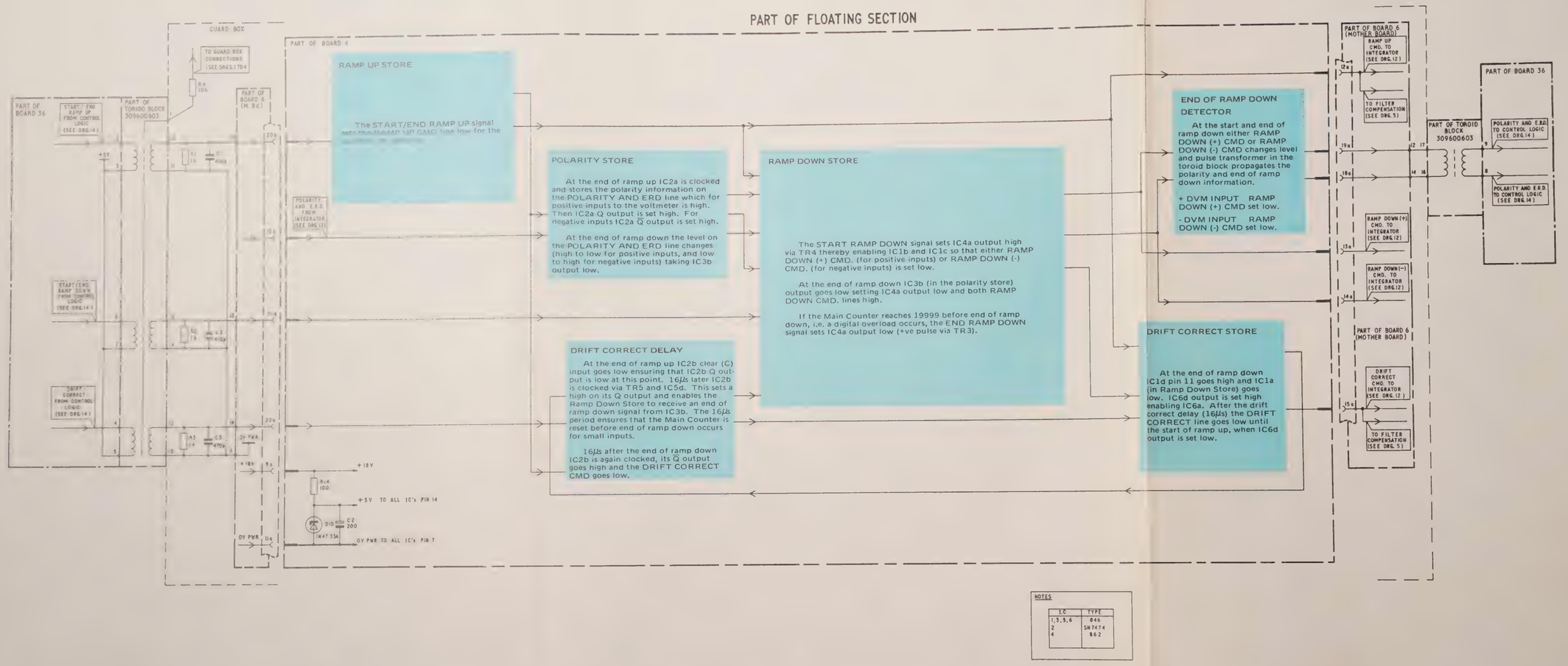
**Scaled Amplifier Output (From DRG 5) is 6.4V for a "19999" Dvm Input, and is -VE for a +VE Input.**




INTEGRATOR CIRCUIT 12

JR/A200/2

7.12.6


PART OF FLOATING SECTION
GUARD BOX
PART OF BOARD 4
TO GUARD BOX CONNECTIONS (SEE DRG. LTD 4)
R4 10k
PART OF BOARD 36
START / END RAMP UP FROM CONTROL LOGIC (SEE DRG. 14)
PART OF TOROID BLOCK 309600603
PART OF BOARD 5 (M. Bd.)
+5V
R1 1k
C 470p
POLARITY AND E.R.D. FROM INTEGRATOR (SEE DRG. 12)
START / END RAMP DOWN FROM CONTROL LOGIC (SEE DRG. 14)
R2 1k
DELAY CORRECT FROM CONTROL LOGIC (SEE DRG. 14)
R3 1k
C3 470p
0V PWR
+18V
R4 100
+5V TO ALL IC's PIN 14
D10 IN4735A
C2 200
0V PWR TO ALL IC's PIN 7
RAMP UP STORE
The START/END RAMP UP signal sets the RAMP UP CMD. line low for the
POLARITY STORE
At the end of ramp up IC2a is clocked and stores the polarity information on the POLARITY AND ERD line which for positive inputs to the voltmeter is high. Then IC2a Q output is set high. For negative inputs IC2a Q̄ output is set high.
At the end of ramp down the level on the POLARITY AND ERD line changes (high to low for positive inputs, and low to high for negative inputs) taking IC3b output low.
RAMP DOWN STORE
The START RAMP DOWN signal sets IC4a output high via TR4 thereby enabling IC1b and IC1c so that either RAMP DOWN (+) CMD. (for positive inputs) or RAMP DOWN (-) CMD. (for negative inputs) is set low.
At the end of ramp down IC3b (in the polarity store) output goes low setting IC4a output low and both RAMP DOWN CMD. lines high.
If the Main Counter reaches 19999 before end of ramp down, i.e. a digital overload occurs, the END RAMP DOWN signal sets IC4a output low (+ve pulse via TR3).
DRIFT CORRECT DELAY
At the end of ramp up IC2b clear (C) input goes low ensuring that IC2b Q output is low at this point. 16μs later IC2b is clocked via TR5 and IC5d. This sets a high on its Q output and enables the Ramp Down Store to receive an end of ramp down signal from IC3b. The 16μs period ensures that the Main Counter is reset before end of ramp down occurs for small inputs.
16μs after the end of ramp down IC2b is again clocked, its Q̄ output goes high and the DRIFT CORRECT CMD goes low.
END OF RAMP DOWN DETECTOR
At the start and end of ramp down either RAMP DOWN (+) CMD or RAMP DOWN (-) CMD changes level and pulse transformer in the toroid block propagates the polarity and end of ramp down information.
+ DVM INPUT RAMP DOWN (+) CMD set low.
- DVM INPUT RAMP DOWN (-) CMD set low.
DRIFT CORRECT STORE
At the end of ramp down IC1d pin 11 goes high and IC1a (in Ramp Down Store) goes low. IC6d output is set high enabling IC6a. After the drift correct delay (16μs) the DRIFT CORRECT line goes low until the start of ramp up, when IC6d output is set low.
PART OF BOARD 6 (MOTHER BOARD)
RAMP UP CMD. TO INTEGRATOR (SEE DRG. 12)
TO FILTER COMPENSATION (SEE DRG. 5)
PART OF TOROID BLOCK 309600603
PART OF BOARD 36
POLARITY AND E.R.D. TO CONTROL LOGIC (SEE DRG. 14)
RAMP DOWN (+) CMD. TO INTEGRATOR (SEE DRG. 12)
RAMP DOWN (-) CMD. TO INTEGRATOR (SEE DRG. 12)
DRIFT CORRECT CMD. TO INTEGRATOR (SEE DRG. 12)
NOTES
IC TYPE
1, 3, 5, 6 846
2 SN7474
4 862

INTEGRATOR CONTROL LOGIC DESCRIPTION

13



JAB/A200/1

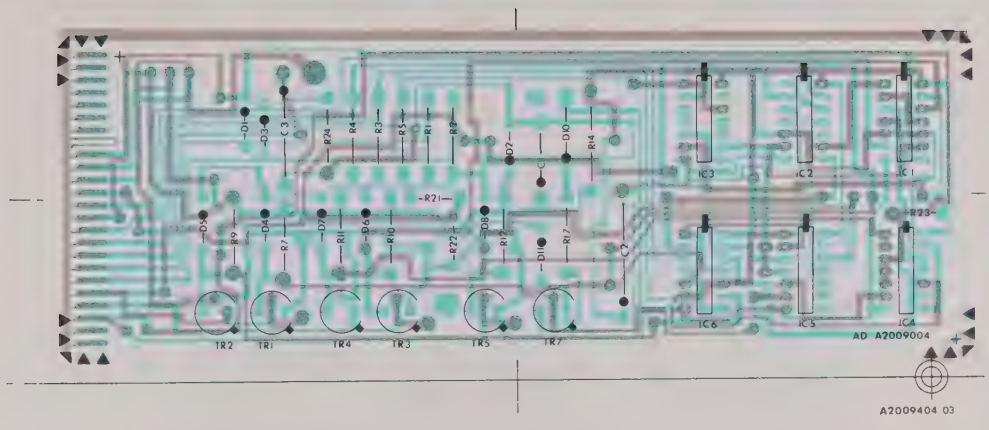



Fig.7.71 Pcb 4

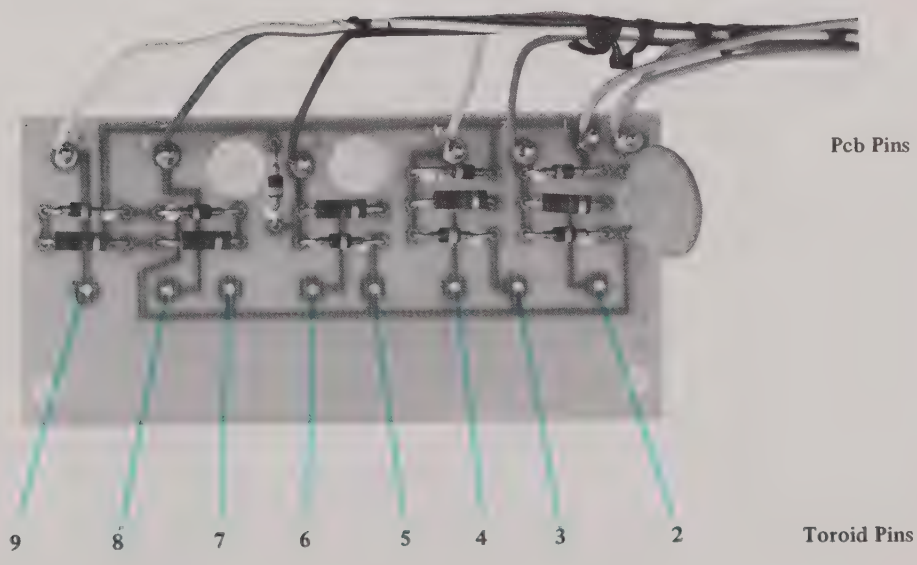



Fig.7.73 Pcb 36 Toroid Pin Connections, Earthy Side

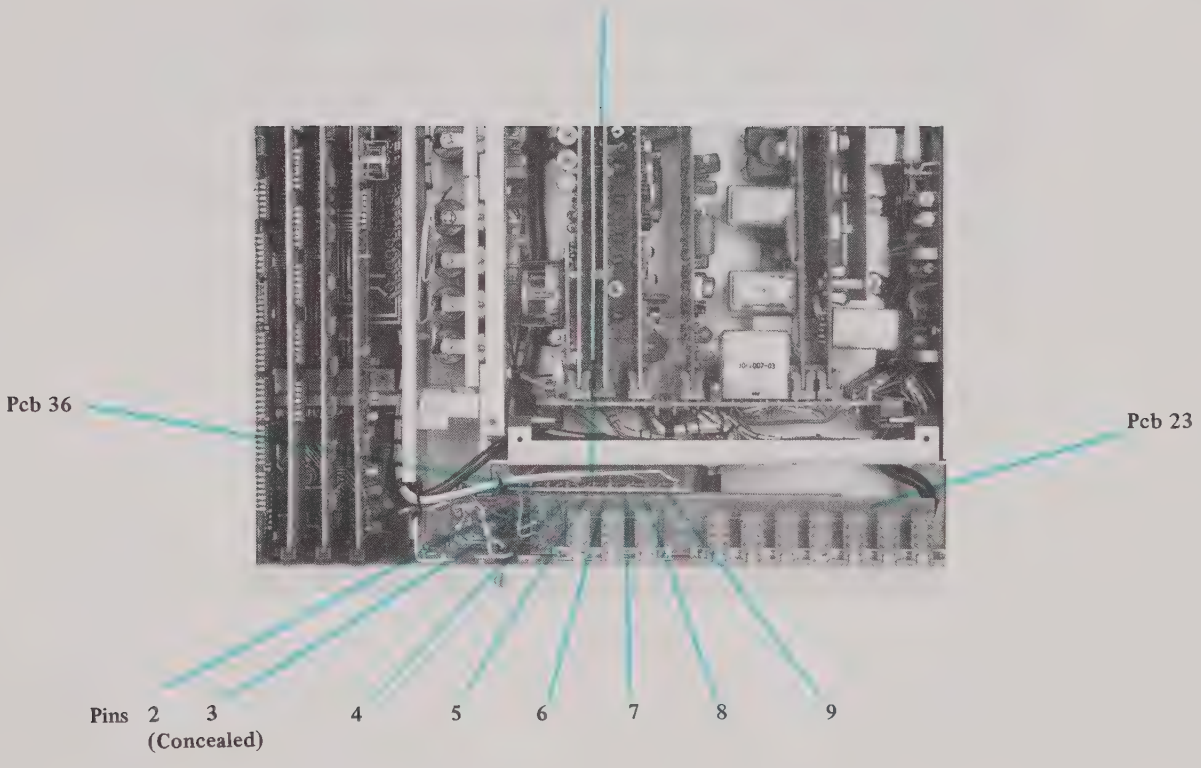



Fig.7.74 Toroid Block Pins, Earthy Side.

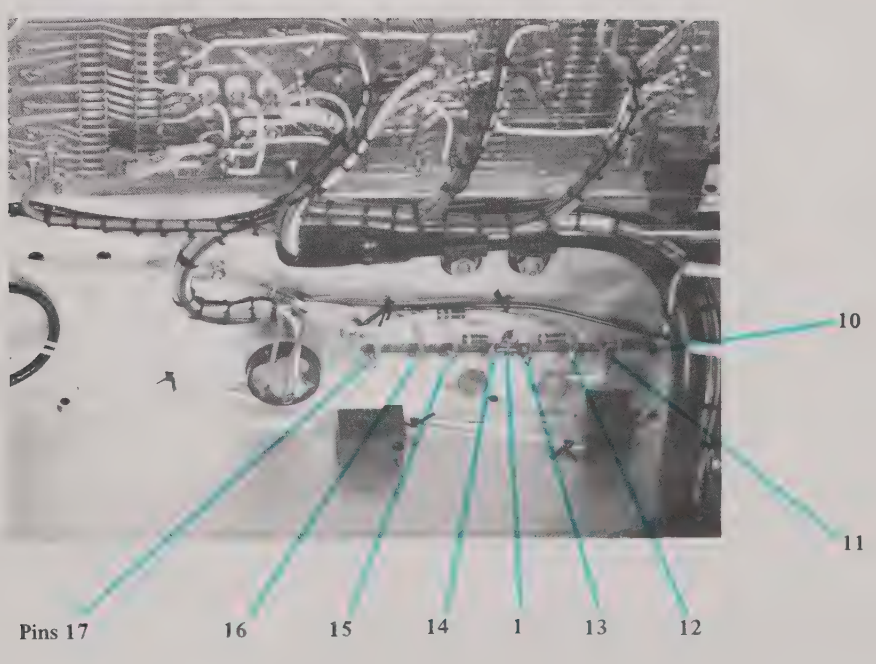
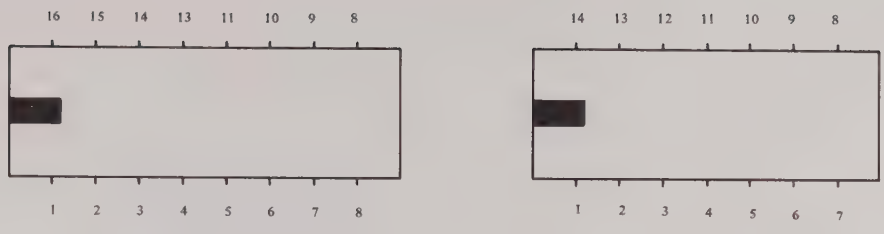



Fig.7.75 Toroid Block Pins, Floating Side




Dual-in-Line IC Pins (Top View)

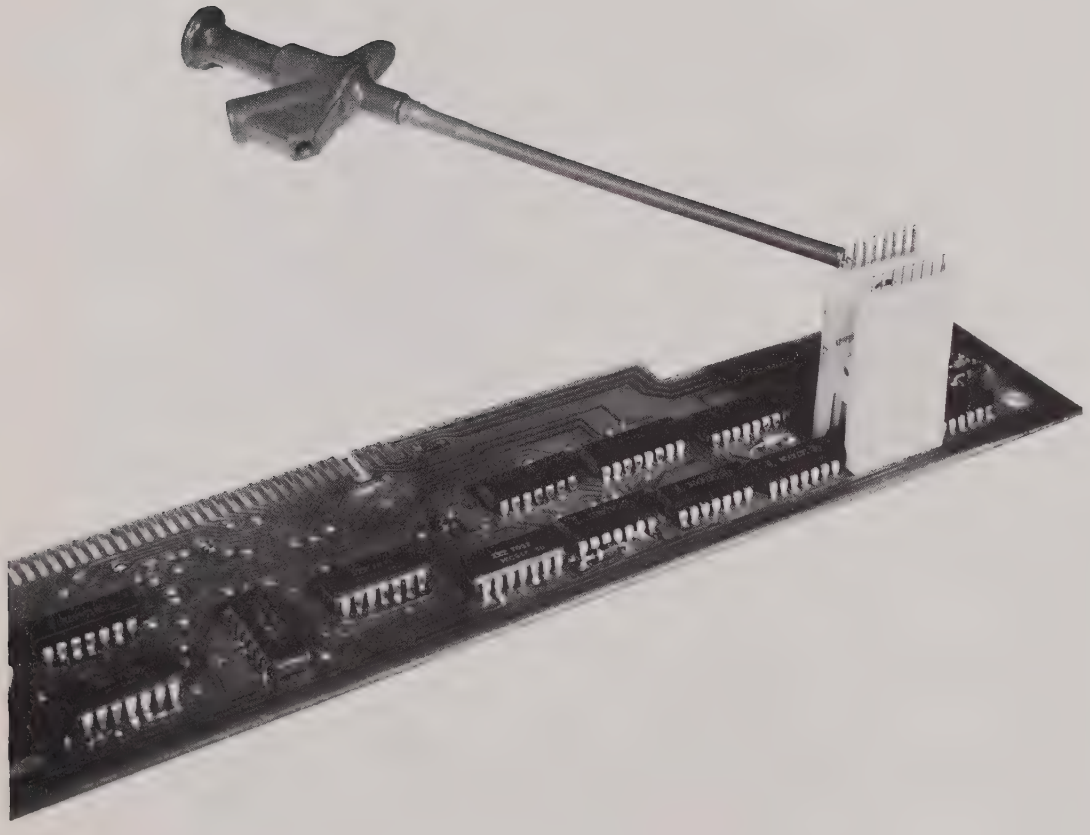


Fig.7.76 Using an IC Pin Clip

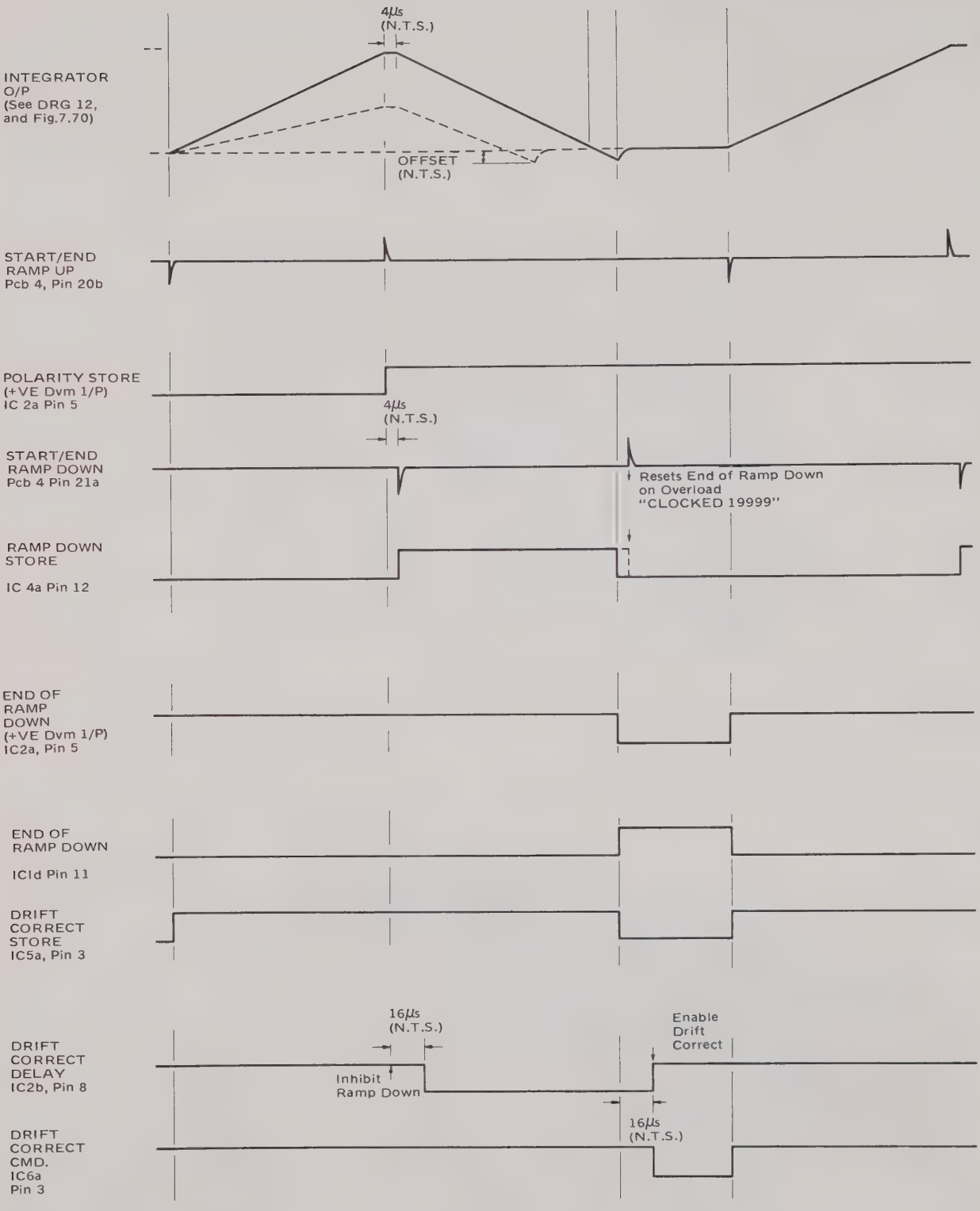
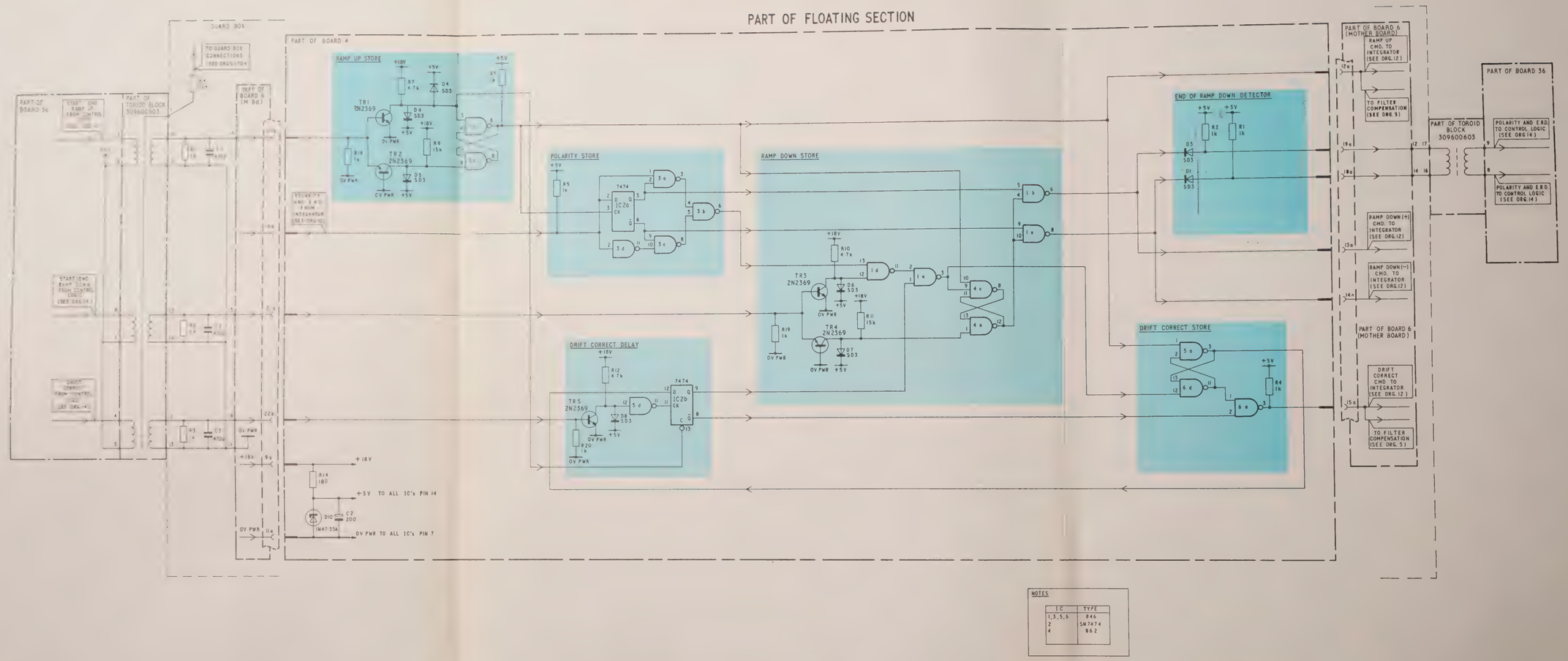

INTEGRATOR O/P (See DRG 12, and Fig.7.70)
4µs (N.T.S.)
OFFSET (N.T.S.)
START/END RAMP UP Pcb 4, Pin 20b
POLARITY STORE (+VE Dvm 1/P) IC 2a Pin 5
4µs (N.T.S.)
START/END RAMP DOWN Pcb 4 Pin 21a
Resets End of Ramp Down on Overload "CLOCKED 19999"
RAMP DOWN STORE
IC 4a Pin 12
END OF RAMP DOWN (+VE Dvm 1/P) IC2a, Pin 5
END OF RAMP DOWN
ICId Pin 11
DRIFT CORRECT STORE IC5a, Pin 3
16µs (N.T.S.)
Enable Drift Correct
DRIFT CORRECT DELAY IC2b, Pin 8
Inhibit Ramp Down
16µs (N.T.S.)
DRIFT CORRECT CMD. IC6a Pin 3

**Fig.7.77 INTEGRATOR CONTROL Waveforms**


PART OF FLOATING SECTION
GUARD BOX
TO GUARD BOX CONNECTIONS (SEE DRG 5 IT 04)
PART OF BOARD 4
PART OF BOARD 36
PART OF TOROID BLOCK 309600503
PART OF BOARD 6 (M Bd)
START END RAMP UP FROM CONTROL
START END RAMP DOWN FROM CONTROL LOGIC (SEE DRG 14)
RAMP UP STORE
POLARITY STORE
RAMP DOWN STORE
DRIFT CORRECT DELAY
END OF RAMP DOWN DETECTOR
DRIFT CORRECT STORE
PART OF BOARD 6 (MOTHER BOARD)
RAMP UP CMD. TO INTEGRATOR (SEE DRG. 12)
TO FILTER COMPENSATION (SEE DRG. 5)
PART OF TOROID BLOCK 309600603
POLARITY AND E.R.D. TO CONTROL LOGIC (SEE DRG 14)
RAMP DOWN (+) CMD. TO INTEGRATOR (SEE DRG 12)
RAMP DOWN (−) CMD. TO INTEGRATOR (SEE DRG 12)
DRIFT CORRECT CMD. TO INTEGRATOR (SEE DRG. 12)
+18V
+5V
0V PWR
+5V TO ALL IC's PIN 14
0V PWR TO ALL IC's PIN 7
IN4735A
7474
TR1 2N2369
TR2 2N2369
TR3 2N2369
TR4 2N2369
TR5 2N2369

NOTES

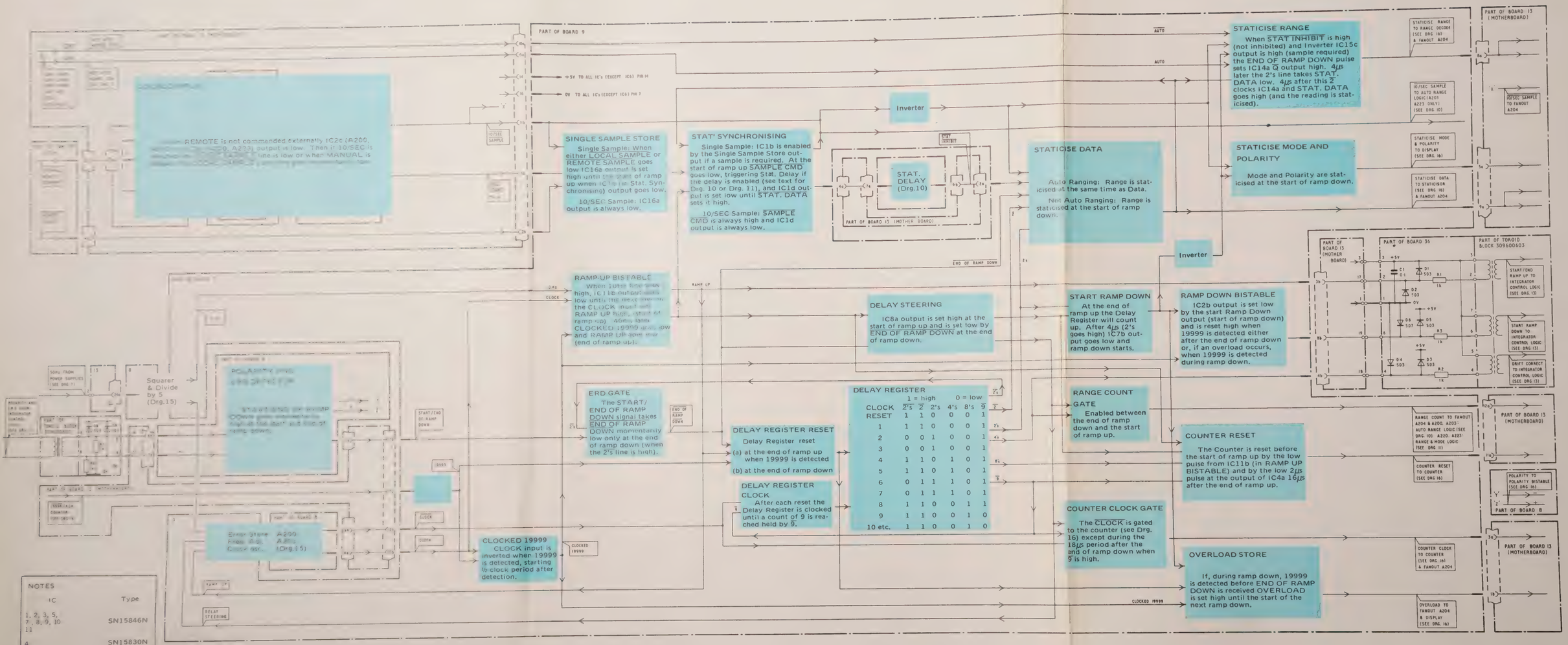
| I C | TYPE |
|---|---|
| 1,3,5,6 | 846 |
| 2 | SN7474 |
| 4 | 862 |

INTEGRATOR CONTROL LOGIC CIRCUIT

13

JR/A200/2

7.13.6


PART OF BOARD 9
+5V TO ALL IC's (EXCEPT IC6) PIN 14
0V TO ALL IC's (EXCEPT IC6) PIN 7
SINGLE SAMPLE STORE
Single Sample: When either LOCAL SAMPLE or REMOTE SAMPLE goes low IC16a output is set high until the start of ramp up when IC1b (in Stat. Synchronising) output goes low.
10/SEC Sample: IC16a output is always low.
STAT' SYNCHRONISING
Single Sample: IC1b is enabled by the Single Sample Store output if a sample is required. At the start of ramp up SAMPLE CMD goes low, triggering Stat. Delay if the delay is enabled (see text for Drg. 10 or Drg. 11), and IC1d output is set low until STAT. DATA sets it high.
10/SEC Sample: SAMPLE CMD is always high and IC1d output is always low.
Inverter
STAT. DELAY (Drg.10)
PART OF BOARD 13 (MOTHER BOARD)
STATICISE DATA
Auto Ranging: Range is staticised at the same time as Data.
Not Auto Ranging: Range is staticised at the start of ramp down.
STATICISE RANGE
When STAT INHIBIT is high (not inhibited) and Inverter IC15c output is high (sample required) the END OF RAMP DOWN pulse sets IC14a Q output high. 4μs later the 2's line takes STAT. DATA low. 4μs after this 2 clocks IC14a and STAT. DATA goes high (and the reading is staticised).
STATICISE MODE AND POLARITY
Mode and Polarity are staticised at the start of ramp down.
STATICISE RANGE TO RANGE DECODE (SEE DRG 16) & FANOUT A204
10/SEC SAMPLE TO AUTO RANGE LOGIC (A203 & A223 ONLY) (SEE DRG 10)
STATICISE MODE & POLARITY TO DISPLAY (SEE DRG 16)
STATICISE DATA TO STATICISOR (SEE DRG 16) & FANOUT A204
10/SEC SAMPLE TO FANOUT A204
PART OF BOARD 13 (MOTHERBOARD)
RAMP-UP BISTABLE
When 1μs line goes high, IC11b output goes low until the next time the CLOCK input goes high. For the RAMP UP high, start of ramp up. 46ms later CLOCKED 19999 goes low and RAMP UP goes low (end of ramp up).
DELAY STEERING
IC8a output is set high at the start of ramp up and is set low by END OF RAMP DOWN at the end of ramp down.
START RAMP DOWN
At the end of ramp up the Delay Register will count up. After 4μs (2's goes high) IC7b output goes low and ramp down starts.
RAMP DOWN BISTABLE
IC2b output is set low by the start Ramp Down output (start of ramp down) and is reset high when 19999 is detected either after the end of ramp down or, if an overload occurs, when 19999 is detected during ramp down.
Inverter
PART OF BOARD 13 (MOTHER BOARD)
PART OF BOARD 36
PART OF TOROID BLOCK 309600603
START/END RAMP UP TO INTEGRATOR CONTROL LOGIC (SEE DRG 13)
START RAMP DOWN TO INTEGRATOR CONTROL LOGIC (SEE DRG 13)
DRIFT CORRECT TO INTEGRATOR CONTROL LOGIC (SEE DRG 13)
ERD GATE
The START/END OF RAMP DOWN signal takes END OF RAMP DOWN momentarily low only at the end of ramp down (when the 2's line is high).
DELAY REGISTER RESET
Delay Register reset
(a) at the end of ramp up when 19999 is detected
(b) at the end of ramp down
DELAY REGISTER CLOCK
After each reset the Delay Register is clocked until a count of 9 is reached held by 9.
DELAY REGISTER
1 = high 0 = low
CLOCK RESET 1 2's 1 2's 1 4's 1 8's 1 9
1 1 1 0 0 0 1
2 0 0 1 0 0 1
3 0 0 1 0 0 1
4 1 1 0 1 0 1
5 1 1 0 1 0 1
6 0 1 1 1 0 1
7 0 1 1 1 0 1
8 1 1 0 0 1 1
9 1 1 0 0 1 0
10 etc. 1 1 0 0 1 0
RANGE COUNT GATE
Enabled between the end of ramp down and the start of ramp up.
COUNTER RESET
The Counter is reset before the start of ramp up by the low pulse from IC11b (in RAMP UP BISTABLE) and by the low 2μs pulse at the output of IC4a 16μs after the end of ramp up.
RANGE COUNT TO FANOUT A204 & A200, A203 : AUTO RANGE LOGIC (SEE DRG 10) A220, A225 : RANGE & MODE LOGIC (SEE DRG 11)
COUNTER RESET TO COUNTER (SEE DRG 16)
POLARITY TO POLARITY BISTABLE (SEE DRG 16)
PART OF BOARD 8
COUNTER CLOCK GATE
The CLOCK is gated to the counter (see Drg. 16) except during the 18μs period after the end of ramp down when 9 is high.
OVERLOAD STORE
If, during ramp down, 19999 is detected before END OF RAMP DOWN is received OVERLOAD is set high until the start of the next ramp down.
COUNTER CLOCK TO COUNTER (SEE DRG 16) & FANOUT A204
OVERLOAD TO FANOUT A204 & DISPLAY (SEE DRG 16)
CLOCKED 19999
CLOCKED 19999 is inverted when 19999 is detected, starting ½ clock period after detection.
Squarer & Divide by 5 (Drg.15)
Error Stops A200 Freq. Osc. A223 Count err. (Drg.15)
START/END OF RAMP DOWN
RAMP UP
DELAY STEERING
CLOCK
SYNC
AUTO
AUTO

| NOTES | |
|---|---|
| IC | Type |
| 1, 2, 3, 5, 7, 8, 9, 10 | SN15846N |
| 11 | |
| 4 | SN15830N |
| 6 | SN7490N |
| 12, 13 | SN158093N |
| 14 | SN7474 |
| 15 | SN15836N |
| 16 | SN15862N |

CONTROL LOGIC DESCRIPTION 14

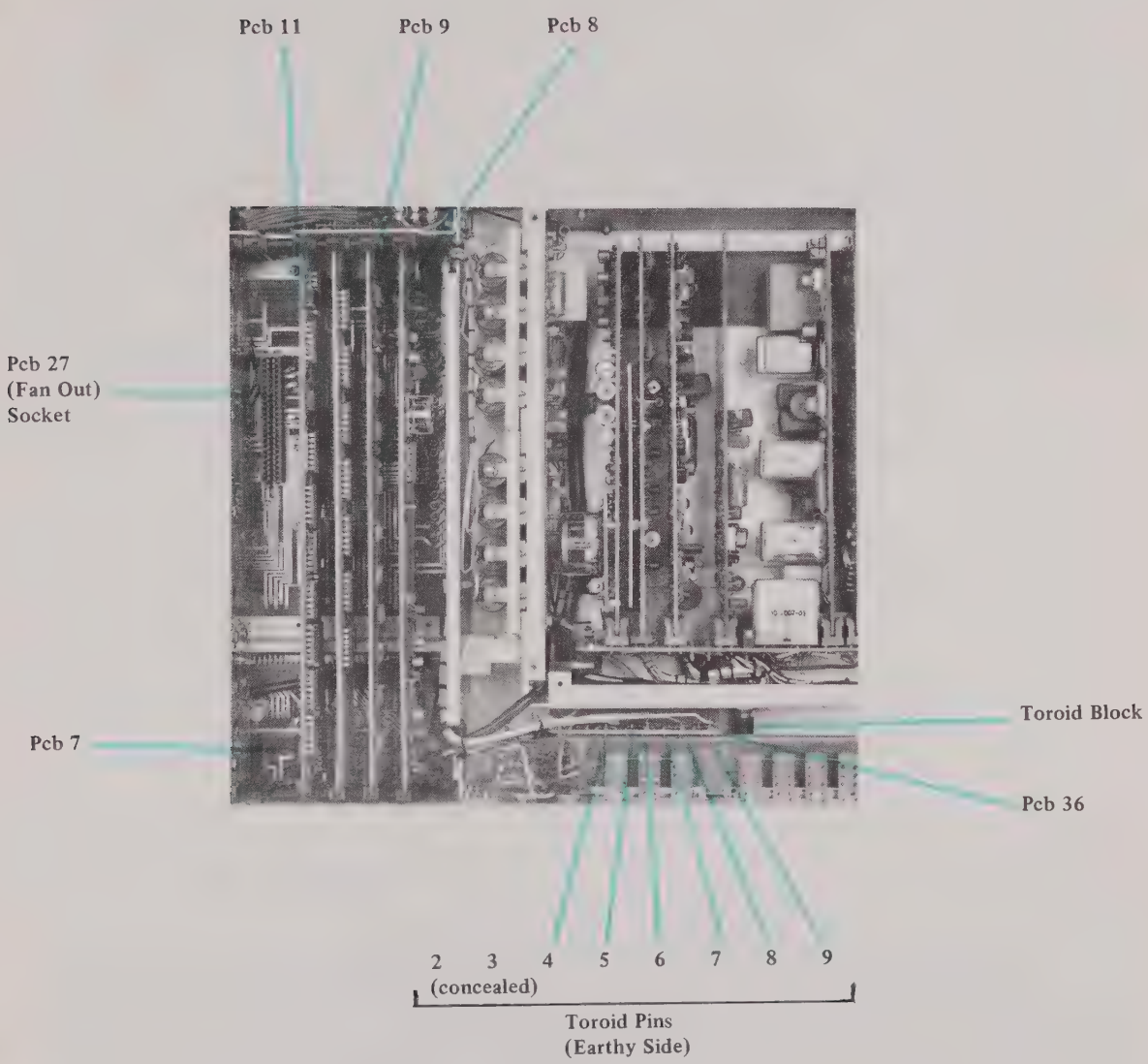



Fig.7.78 Pcb 36 and Toroid Block Location

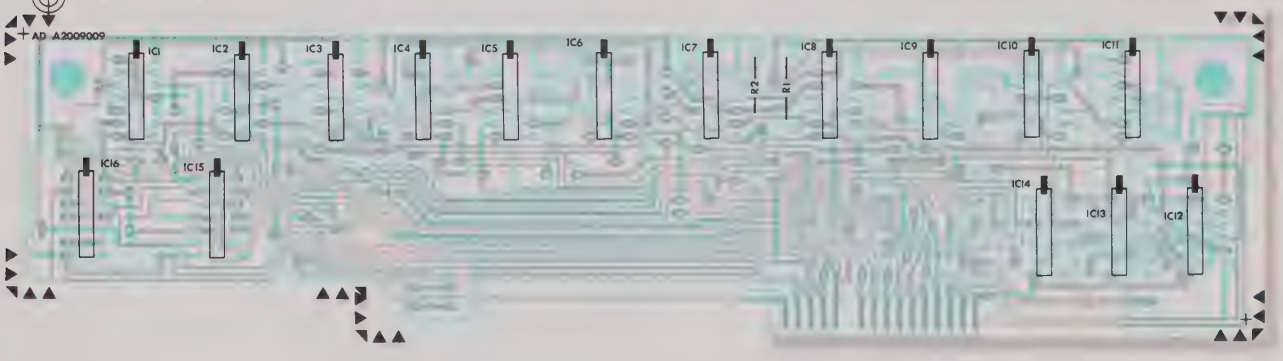



Fig.7.79 Pcb 9

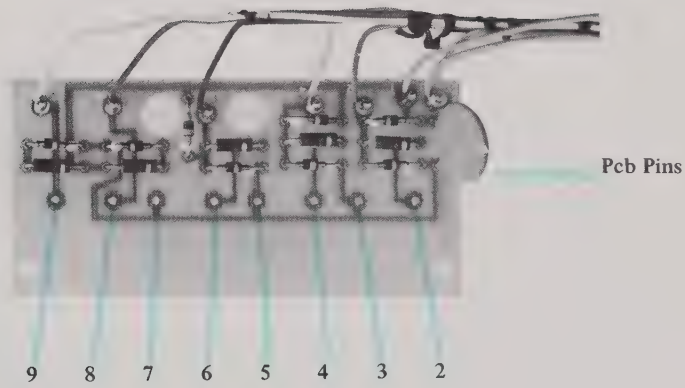



Fig.7.81 Pcb 36 Toroid Pin Connections, Earthy Side (Shown as fitted)

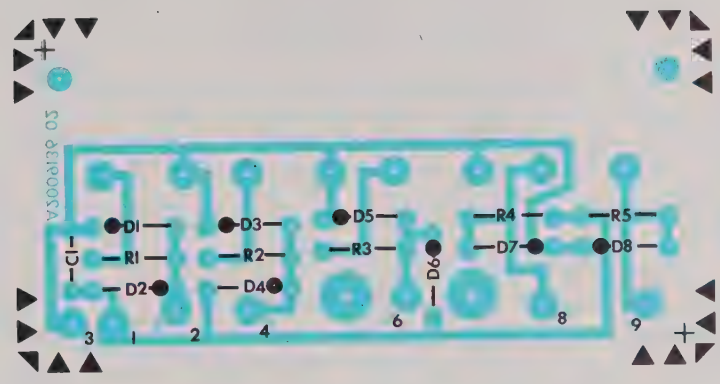



Fig.7.82 Pcb 36

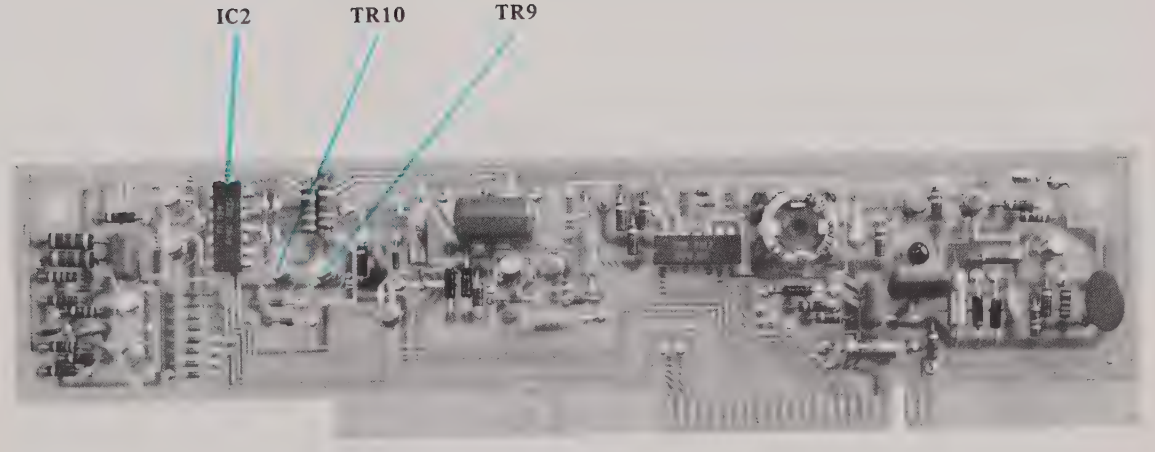
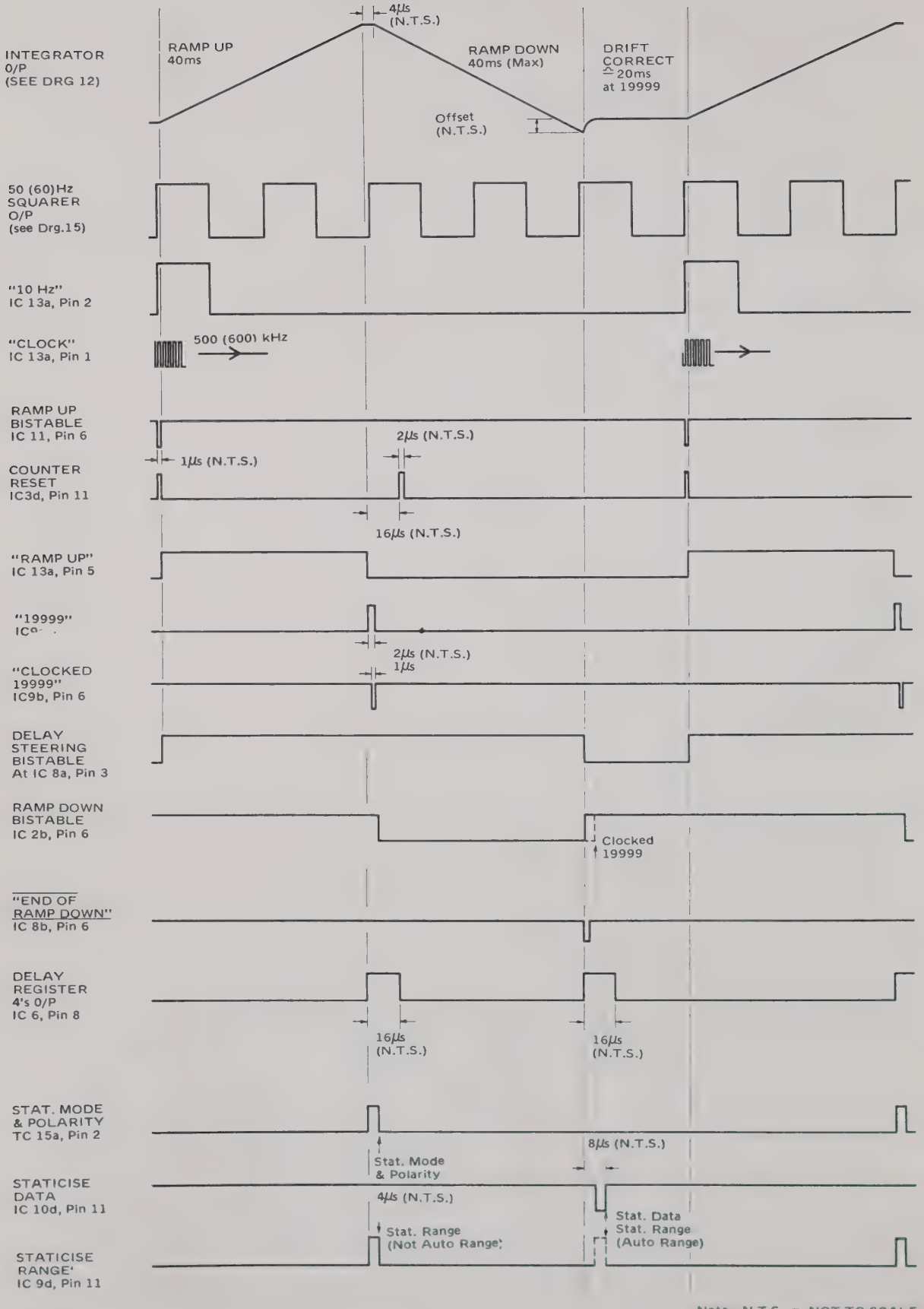
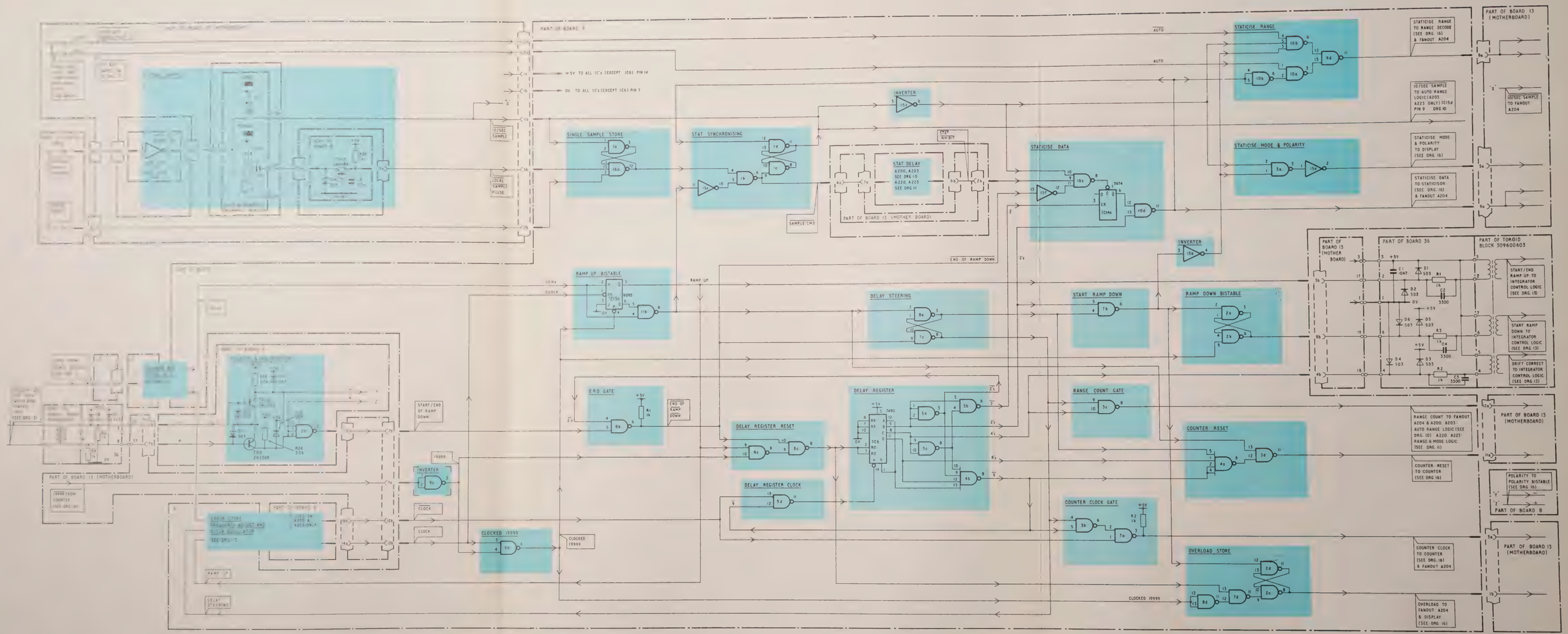



Fig.7.84 Pcb 8 A200, A203. TR9, TR10 and IC2


INTEGRATOR O/P (SEE DRG 12)
4μs (N.T.S.)
RAMP UP 40ms
RAMP DOWN 40ms (Max)
DRIFT CORRECT ≙ 20ms at 19999
Offset (N.T.S.)
50 (60)Hz SQUARER O/P (see Drg.15)
"10 Hz" IC 13a, Pin 2
"CLOCK" IC 13a, Pin 1
500 (600) kHz
RAMP UP BISTABLE IC 11, Pin 6
2μs (N.T.S.)
1μs (N.T.S.)
COUNTER RESET IC3d, Pin 11
16μs (N.T.S.)
"RAMP UP" IC 13a, Pin 5
"19999" IC
2μs (N.T.S.)
1μs
"CLOCKED 19999" IC9b, Pin 6
DELAY STEERING BISTABLE At IC 8a, Pin 3
RAMP DOWN BISTABLE IC 2b, Pin 6
Clocked 19999
"END OF RAMP DOWN" IC 8b, Pin 6
DELAY REGISTER 4's O/P IC 6, Pin 8
16μs (N.T.S.)
16μs (N.T.S.)
STAT. MODE & POLARITY TC 15a, Pin 2
8μs (N.T.S.)
Stat. Mode & Polarity
STATICISE DATA IC 10d, Pin 11
4μs (N.T.S.)
Stat. Range (Not Auto Range)
Stat. Data
Stat. Range (Auto Range)
STATICISE RANGE' IC 9d, Pin 11

Note: N.T.S. = NOT TO SCALE

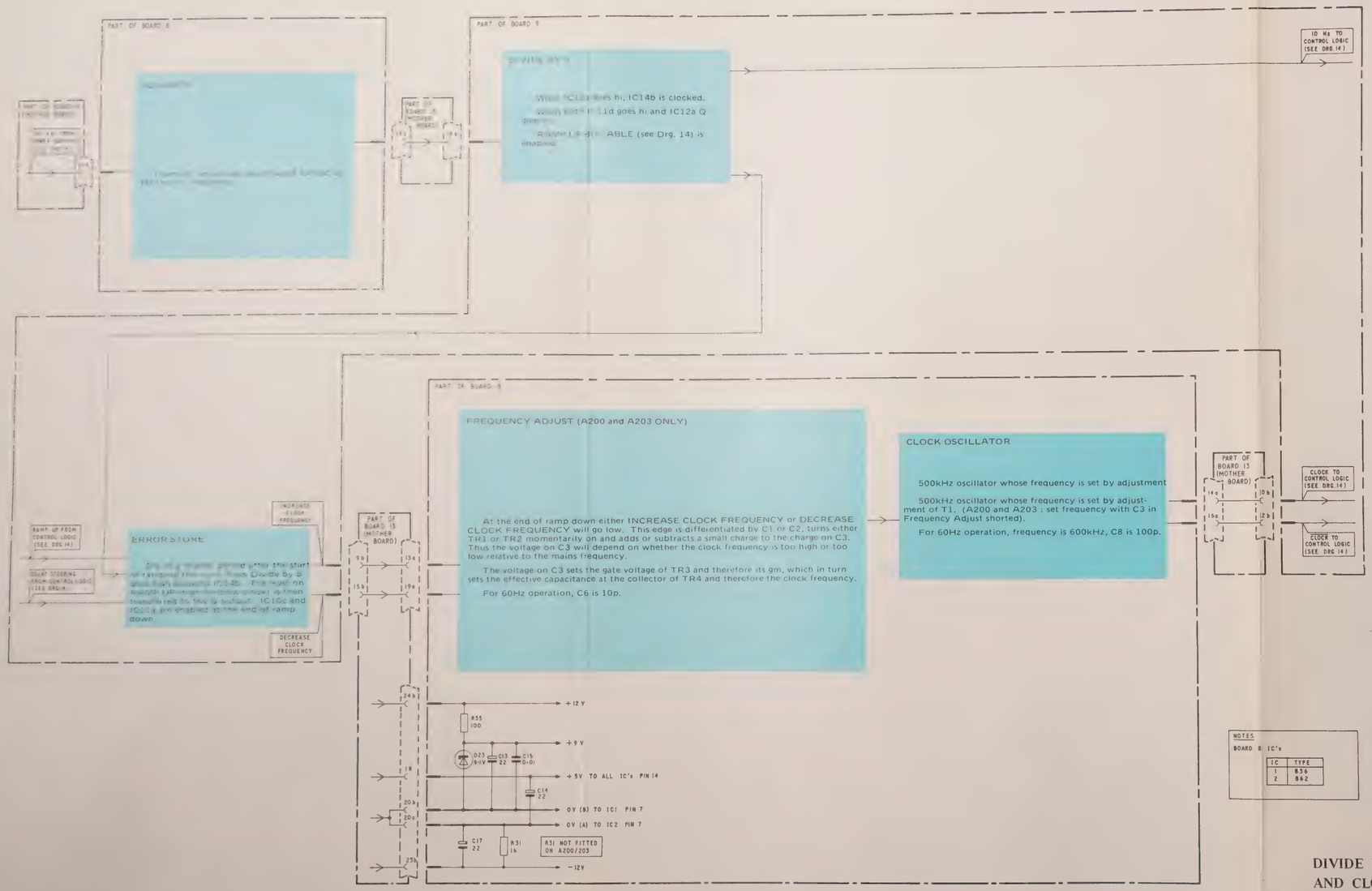
**Fig.7.85 CONTROL LOGIC WAVEFORMS**


PART OF BOARD 9
+5V TO ALL IC's (EXCEPT IC6) PIN 14
0V TO ALL IC's (EXCEPT IC6) PIN 7
10/SEC SAMPLE
LOCAL SAMPLE PULSE
SINGLE SAMPLE STORE
STAT SYNCHRONISING
INVERTER
STAT DELAY
A200, A203 SEE DRG 10 A220, A223 SEE DRG 11
SAMPLE CMD
PART OF BOARD 13 (MOTHER BOARD)
END OF RAMP DOWN
STATICISE DATA
AUTO
STATICISE RANGE
STATICISE RANGE TO RANGE DECODE (SEE DRG 16) & FANOUT A204
10/SEC SAMPLE TO AUTO RANGE LOGIC (A203 A223 ONLY) IC15d PIN 9 DRG 10
10/SEC SAMPLE TO FANOUT A204
STATICISE MODE & POLARITY
STATICISE MODE & POLARITY TO DISPLAY (SEE DRG 16)
STATICISE DATA TO STATICISOR (SEE DRG 16) & FANOUT A204
PART OF BOARD 13 (MOTHERBOARD)
RAMP UP BISTABLE
RAMP UP
DELAY STEERING
START RAMP DOWN
RAMP DOWN BISTABLE
PART OF BOARD 15 (MOTHER BOARD)
PART OF BOARD 36
PART OF TOROID BLOCK 309600803
START/END RAMP UP TO INTEGRATOR CONTROL LOGIC (SEE DRG 13)
START RAMP DOWN TO INTEGRATOR CONTROL LOGIC (SEE DRG 13)
DRIFT CORRECT TO INTEGRATOR CONTROL LOGIC (SEE DRG 13)
END GATE
DELAY REGISTER
RANGE COUNT GATE
COUNTER RESET
RANGE COUNT TO FANOUT A204 & A200, A203: AUTO RANGE LOGIC (SEE DRG 10) A220 A223: RANGE & MODE LOGIC (SEE DRG 11)
COUNTER RESET TO COUNTER (SEE DRG 16)
POLARITY TO POLARITY BISTABLE (SEE DRG 16)
PART OF BOARD 8
DELAY REGISTER RESET
DELAY REGISTER CLOCK
COUNTER CLOCK GATE
OVERLOAD STORE
CLOCKED 19999
COUNTER CLOCK TO COUNTER (SEE DRG 16) & FANOUT A204
OVERLOAD TO FANOUT A204 & DISPLAY (SEE DRG 16)
START/END OF RAMP DOWN
19999
CLOCK
INVERTER
19999 FROM COUNTER (SEE DRG 16)
ERROR STORE
USED ON A200 & A203 ONLY
SEE DRG 5
RAMP UP
DELAY STEERING

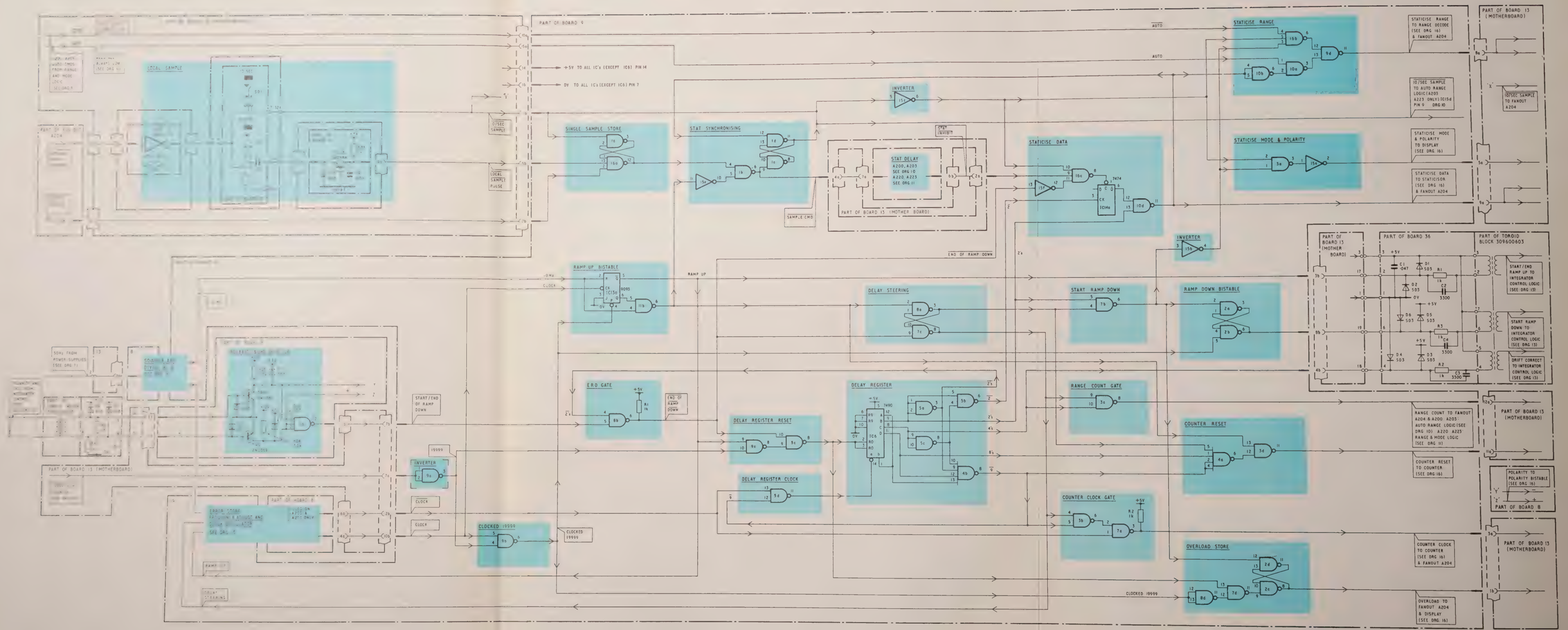
CONTROL LOGIC CIRCUIT **14**

JR/A200/2

7.14.6


PART OF BOARD 8
PART OF BOARD 9
DIVIDE BY 5
Whilst IC11a goes hi, IC14b is clocked,
ABLE (see Drg. 14) is
10 Hz TO CONTROL LOGIC (SEE DRG.14)
PART OF BOARD 8
FREQUENCY ADJUST (A200 and A203 ONLY)
At the end of ramp down either INCREASE CLOCK FREQUENCY or DECREASE CLOCK FREQUENCY will go low. This edge is differentiated by C1 or C2, turns either TR1 or TR2 momentarily on and adds or subtracts a small charge to the charge on C3. Thus the voltage on C3 will depend on whether the clock frequency is too high or too low relative to the mains frequency.
The voltage on C3 sets the gate voltage of TR3 and therefore its gm, which in turn sets the effective capacitance at the collector of TR4 and therefore the clock frequency.
For 60Hz operation, C6 is 10p.
CLOCK OSCILLATOR
500kHz oscillator whose frequency is set by adjustment
500kHz oscillator whose frequency is set by adjustment of T1. (A200 and A203 : set frequency with C3 in Frequency Adjust shorted).
For 60Hz operation, frequency is 600kHz, C8 is 100p.
PART OF BOARD 13 (MOTHER BOARD)
CLOCK TO CONTROL LOGIC (SEE DRG.14)
CLOCK TO CONTROL LOGIC (SEE DRG.14)
RAMP UP FROM CONTROL LOGIC (SEE DRG.14)
DELAY STEERING FROM CONTROL LOGIC (SEE DRG.14)
ERROR STORE
INCREASE CLOCK FREQUENCY
DECREASE CLOCK FREQUENCY
PART OF BOARD 13 (MOTHER BOARD)
+12 V
R35 100
+9 V
D23 9·1V
C13 22
C15 0·01
+5V TO ALL IC's PIN 14
C14 22
0V (B) TO IC1 PIN 7
0V (A) TO IC2 PIN 7
C17 22
R31 1k
R31 NOT FITTED ON A200/203
−12V
NOTES
BOARD 8 IC's
IC TYPE
1 B36
2 B62

DIVIDE BY 5 AND CLOCK DESCRIPTION 15


PART OF BOARD 9
+5V TO ALL IC's (EXCEPT IC6) PIN 14
0V TO ALL IC's (EXCEPT IC6) PIN 7
LOCAL SAMPLE
0.1SEC SAMPLE
LOCAL SAMPLE PULSE
SINGLE SAMPLE STORE
STAT SYNCHRONISING
INVERTER
STAT DELAY
A200, A203 SEE DRG 10
A220, A223 SEE DRG 11
PART OF BOARD 13 (MOTHER BOARD)
SAMPLE CMD
OVEN INHIBIT
STATICISE DATA
STATICISE RANGE
STATICISE MODE & POLARITY
AUTO
STATICISE RANGE TO RANGE DECODE (SEE DRG 16) & FANOUT A204
10/SEC SAMPLE TO AUTO RANGE LOGIC (A203 A223 ONLY) IC15d PIN 9 DRG 10
STATICISE MODE & POLARITY TO DISPLAY (SEE DRG 16)
STATICISE DATA TO STATICISOR (SEE DRG 16) & FANOUT A204
10/SEC SAMPLE TO FANOUT A204
PART OF BOARD 13 (MOTHERBOARD)
PART OF BOARD 36
PART OF TOROID BLOCK 309800603
START/END RAMP UP TO INTEGRATOR CONTROL LOGIC (SEE DRG 13)
START RAMP DOWN TO INTEGRATOR CONTROL LOGIC (SEE DRG 13)
DRIFT CORRECT TO INTEGRATOR CONTROL LOGIC (SEE DRG 13)
RAMP UP BISTABLE
RAMP UP
ZONE
CLOCK
END OF RAMP DOWN
DELAY STEERING
START RAMP DOWN
RAMP DOWN BISTABLE
50Hz FROM POWER SUPPLIES (SEE DRG 7)
ERO GATE
DELAY REGISTER
DELAY REGISTER RESET
DELAY REGISTER CLOCK
RANGE COUNT GATE
COUNTER RESET
COUNTER CLOCK GATE
OVERLOAD STORE
START/END OF RAMP DOWN
END OF RAMP DOWN
CLOCKED 19999
RANGE COUNT TO FANOUT A204 & A200 A203 AUTO RANGE LOGIC (SEE DRG 10) A220 A223 RANGE & MODE LOGIC (SEE DRG 11)
COUNTER RESET TO COUNTER (SEE DRG 16)
COUNTER CLOCK TO COUNTER (SEE DRG 16) & FANOUT A204
OVERLOAD TO FANOUT A204 & DISPLAY (SEE DRG 16)
POLARITY TO POLARITY BISTABLE (SEE DRG 16)
PART OF BOARD 8

CONTROL LOGIC CIRCUIT 14

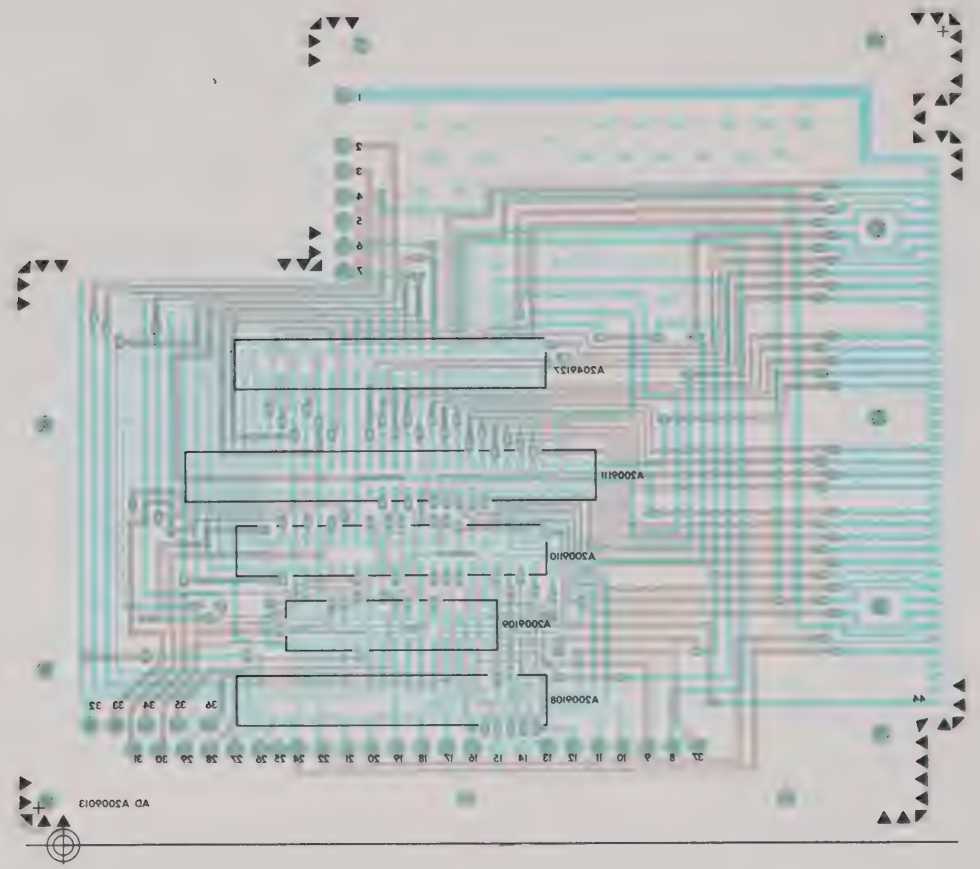


Fig.7.89 Pcb 13 Earthy Mother Board

Fig.7.91 Pcb 9 Divide by 5 and Error Store IC's

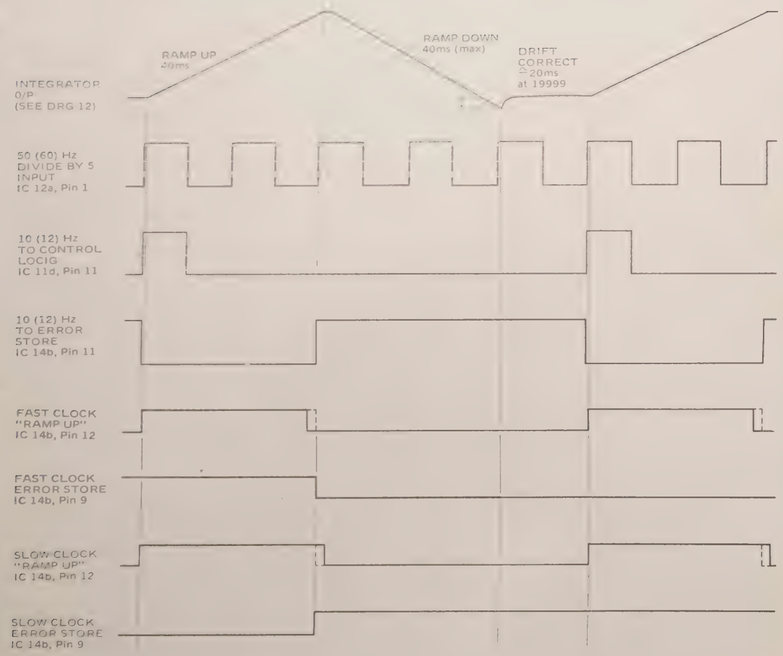
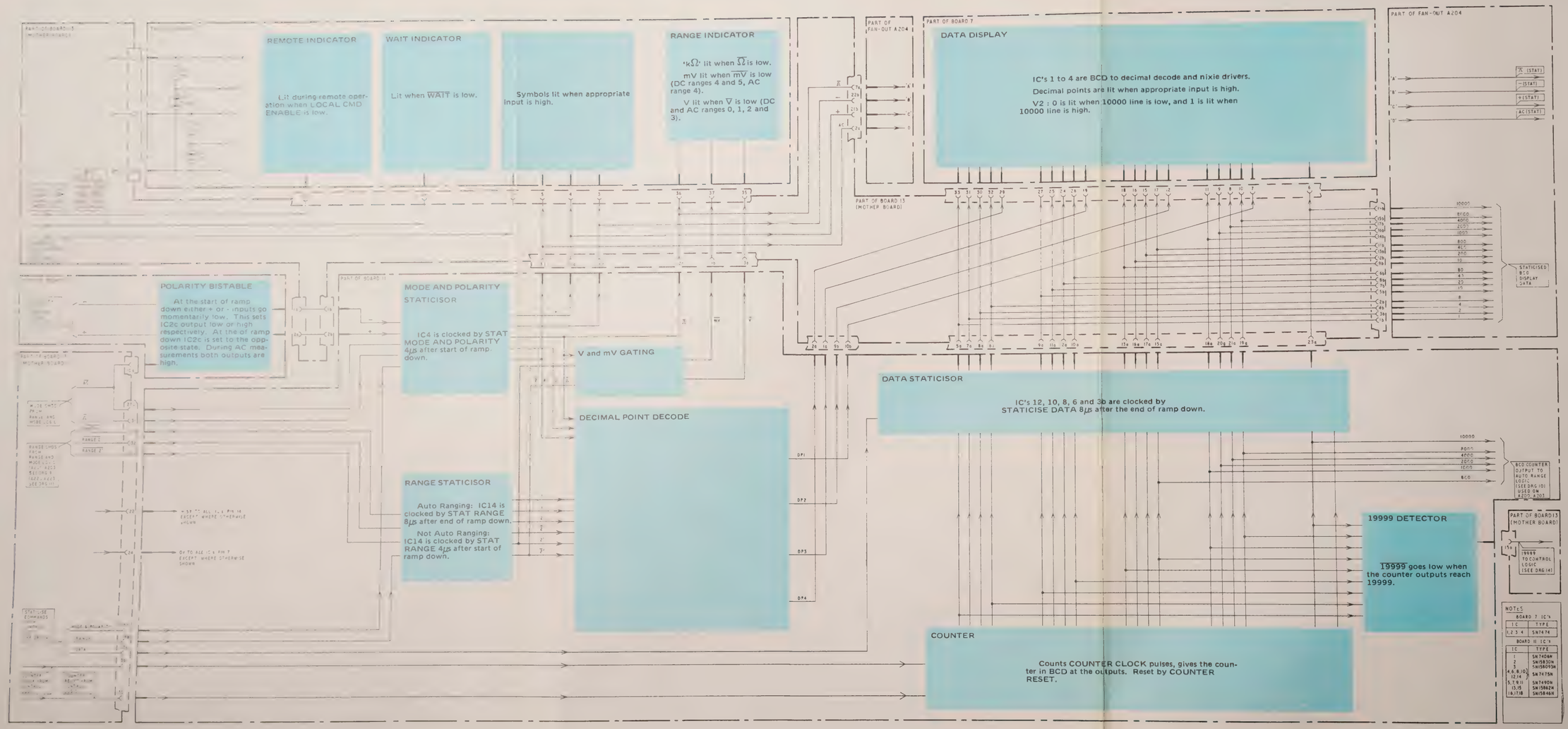

RAMP UP
20ms
RAMP DOWN
40ms (max)
DRIFT CORRECT
±20ms
at 19999
INTEGRATOR O/P (SEE DRG 12)
50 (60) Hz DIVIDE BY 5 INPUT IC 12a, Pin 1
10 (12) Hz TO CONTROL LOGIC IC 11d, Pin 11
10 (12) Hz TO ERROR STORE IC 14b, Pin 11
FAST CLOCK "RAMP UP" IC 14b, Pin 12
FAST CLOCK ERROR STORE IC 14b, Pin 9
SLOW CLOCK "RAMP UP" IC 14b, Pin 12
SLOW CLOCK ERROR STORE IC 14b, Pin 9

Fig.7.92 DIVIDE BY 5 AND CLOCK WAVEFORMS

PART OF BOARD 8
SQUARER
PART OF BOARD 13 (MOTHER BOARD)
50 Hz FROM POWER SUPPLIES (SEE DRG 14)
PART OF BOARD 9
DIVIDE BY 5
10 Hz TO CONTROL LOGIC (IC13 PIN 2 DRG 14)
PART OF BOARD 8
FREQUENCY ADJUST (A200, A203 ONLY)
CLOCK OSCILLATOR
T1 CLOCK OSCILLATOR
TP1 SET 500 kHz
PART OF BOARD 13 (MOTHER BOARD)
CLOCK TO CONTROL LOGIC (SEE DRG 14)
CLOCK TO CONTROL LOGIC (SEE DRG 14)
RAMP UP FROM CONTROL LOGIC IC15 PIN 5 DRG 14
DELAY STEERING FROM CONTROL LOGIC IC7 PIN 8 DRG 14
ERROR STORE
INCREASE CLOCK FREQUENCY
DECREASE CLOCK FREQUENCY
PART OF BOARD 13 (MOTHER BOARD)
+12 V
+9 V
+5 V TO ALL IC's PIN 14
0V (B) TO IC1 PIN 7
0V (A) TO IC2 PIN 7
R31 NOT FITTED ON A200/203
−12V
NOTES
BOARD 8 IC's
IC | TYPE
1 | 836
2 | 862

**DIVIDE BY 5 AND CLOCK CIRCUIT** **15**


REMOTE INDICATOR
Lit during remote operation when LOCAL CMD ENABLE is low.
WAIT INDICATOR
Lit when WAIT is low.
Symbols lit when appropriate input is high.
RANGE INDICATOR
'kΩ' lit when kΩ is low.
mV lit when mV is low (DC ranges 4 and 5, AC range 4).
V lit when V is low (DC and AC ranges 0, 1, 2 and 3).
PART OF FAN-OUT A204
PART OF BOARD 7
DATA DISPLAY
IC's 1 to 4 are BCD to decimal decode and nixie drivers.
Decimal points are lit when appropriate input is high.
V2 : 0 is lit when 10000 line is low, and 1 is lit when 10000 line is high.
PART OF FAN-OUT A204
PART OF BOARD 13 (MOTHER BOARD)
STATICISED BCD DISPLAY DATA
POLARITY BISTABLE
At the start of ramp down either + or - inputs go momentarily low. This sets IC2c output low or high respectively. At the of ramp down IC2c is set to the opposite state. During AC measurements both outputs are high.
MODE AND POLARITY STATICISOR
IC4 is clocked by STAT MODE AND POLARITY 4μs after start of ramp down.
V and mV GATING
DECIMAL POINT DECODE
DP1
DP2
DP3
DP4
RANGE STATICISOR
Auto Ranging: IC14 is clocked by STAT RANGE 8μs after end of ramp down.
Not Auto Ranging: IC14 is clocked by STAT RANGE 4μs after start of ramp down.
DATA STATICISOR
IC's 12, 10, 8, 6 and 3b are clocked by STATICISE DATA 8μs after the end of ramp down.
BCD COUNTER OUTPUT TO AUTO RANGE LOGIC (SEE DRG 10) USED ON A200/A203
19999 DETECTOR
19999 goes low when the counter outputs reach 19999.
PART OF BOARD 13 (MOTHER BOARD)
19999 TO CONTROL LOGIC (SEE DRG 14)
COUNTER
Counts COUNTER CLOCK pulses, gives the counter in BCD at the outputs. Reset by COUNTER RESET.
NOTES
BOARD 7 IC's
IC TYPE
1,2,3,4 SN7474
BOARD 11 IC's
IC TYPE
1 SN7404N
2 SN5830N SN58209N
4,6,8,10, 12,14 SN7475N
5,7,9,11, 13,15 SN7490N SN5962N
16,17,18 SN5846N

COUNTER AND DISPLAY DESCRIPTION 16

7.16.1

JAB/A200/1

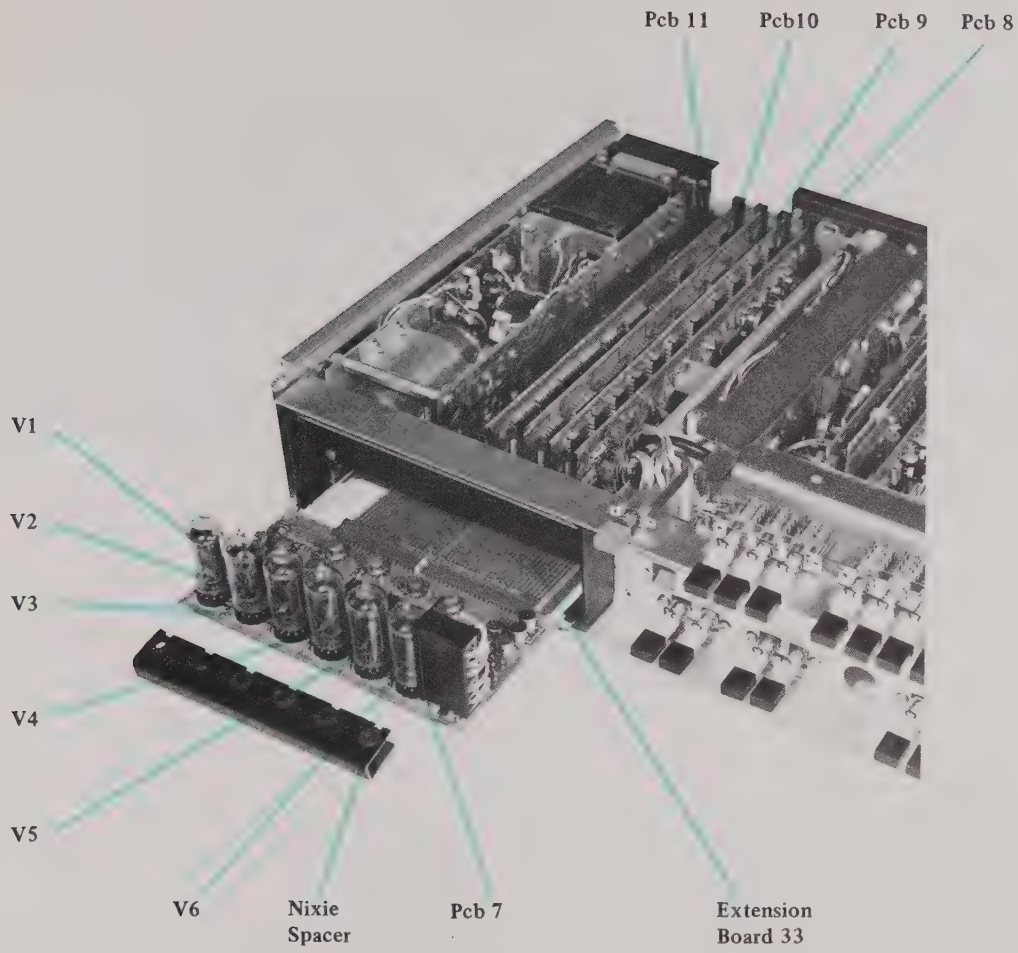



Fig.7.93 Pcb 7 on Extension Board 33

V1 to V6 Access

1) Remove the Top Cover.
2) Remove the two side handles.
3) Remove the Top Front Bar (A2000101).
4) Remove the Display Cover.

Ensuring the dvm is OFF, pcb 7 may now be eased from its socket using flat nosed pliers. If a Nixie Spacer is supplied, the tubes may be unplugged. If not, they can be readily unsoldered from the base and then removed.

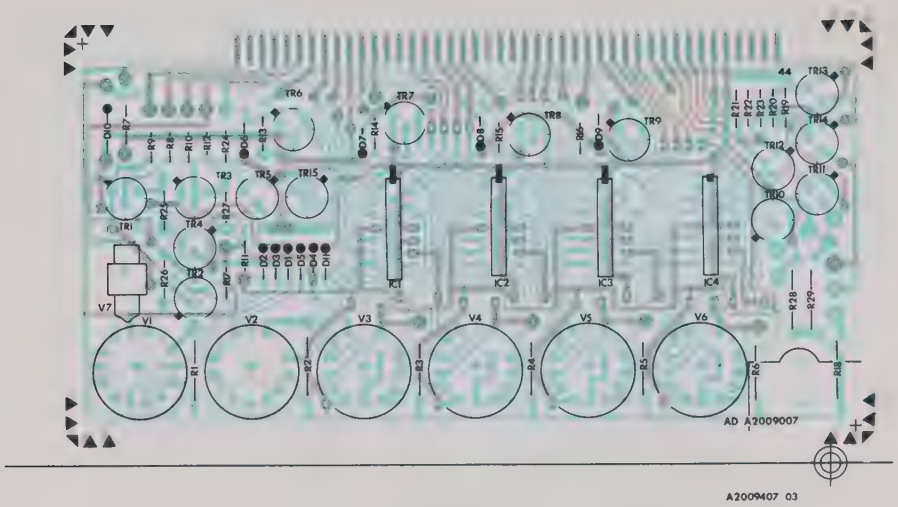
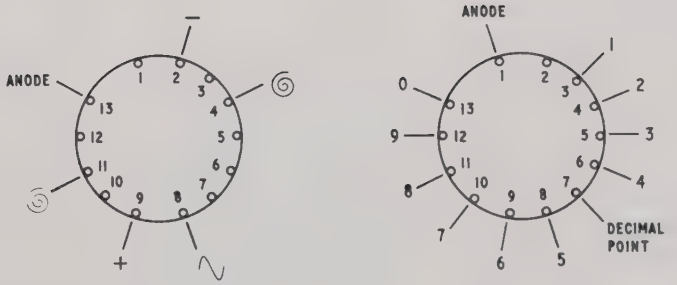



Fig.7.94 Pcb 7




ZM 1263/C ZM 175/C

Fig.7.96 Display Tube Bases

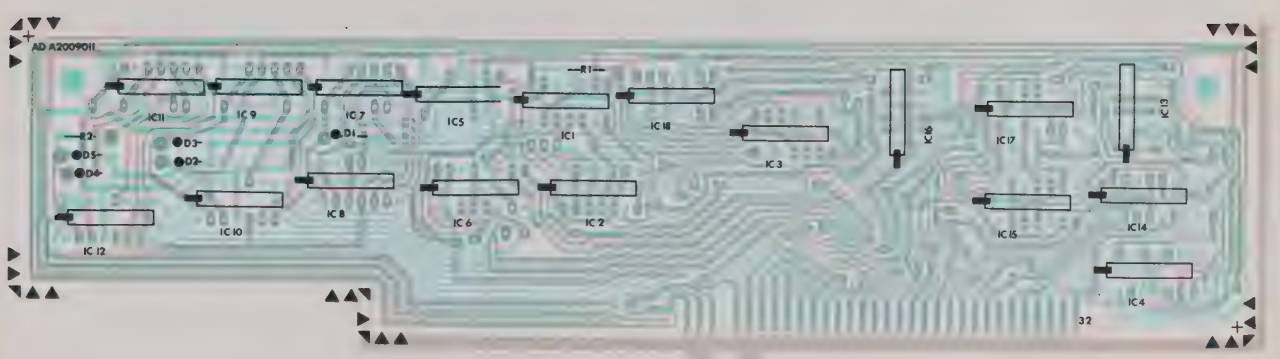



Fig. 7. 97 Pcb 11

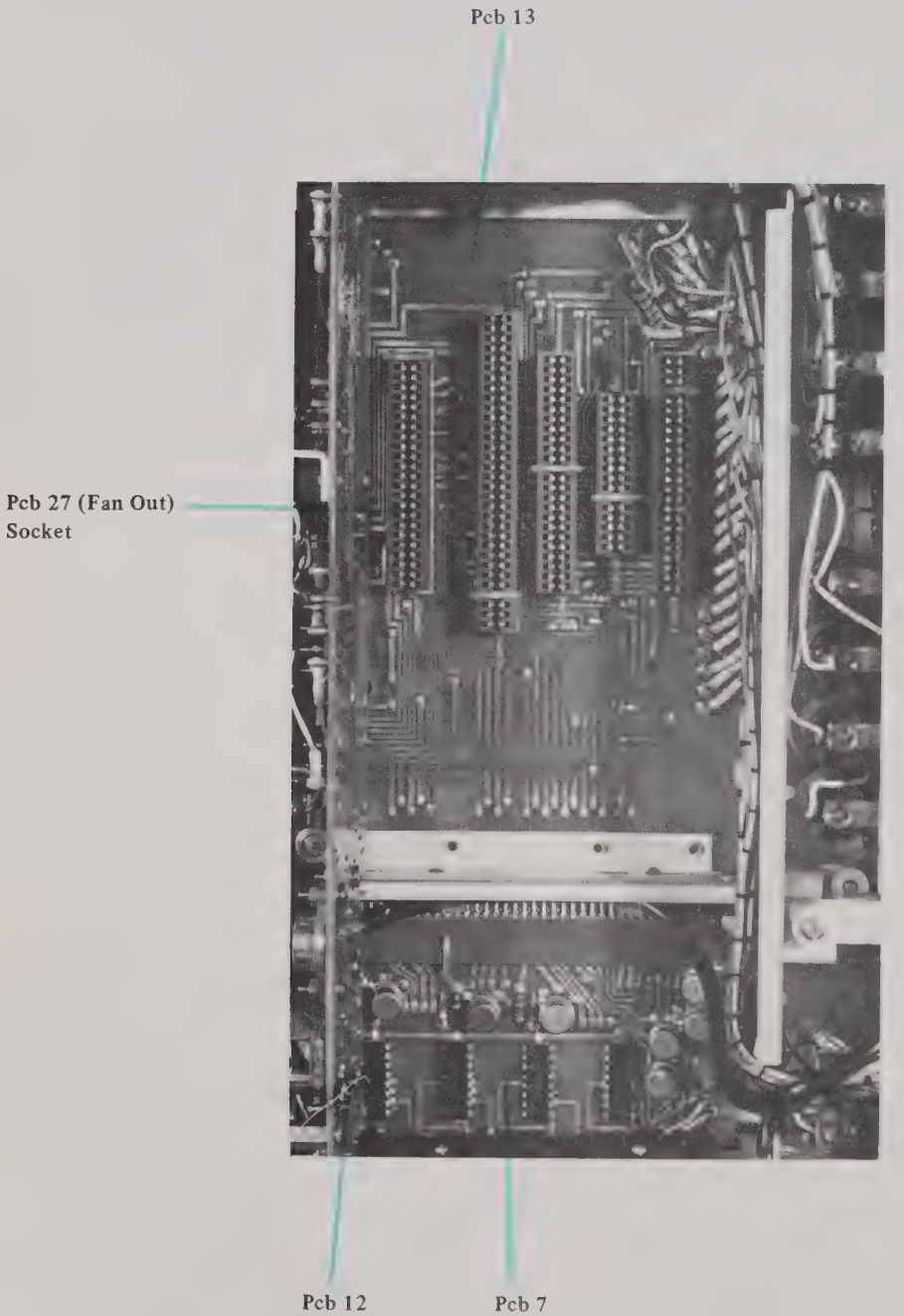
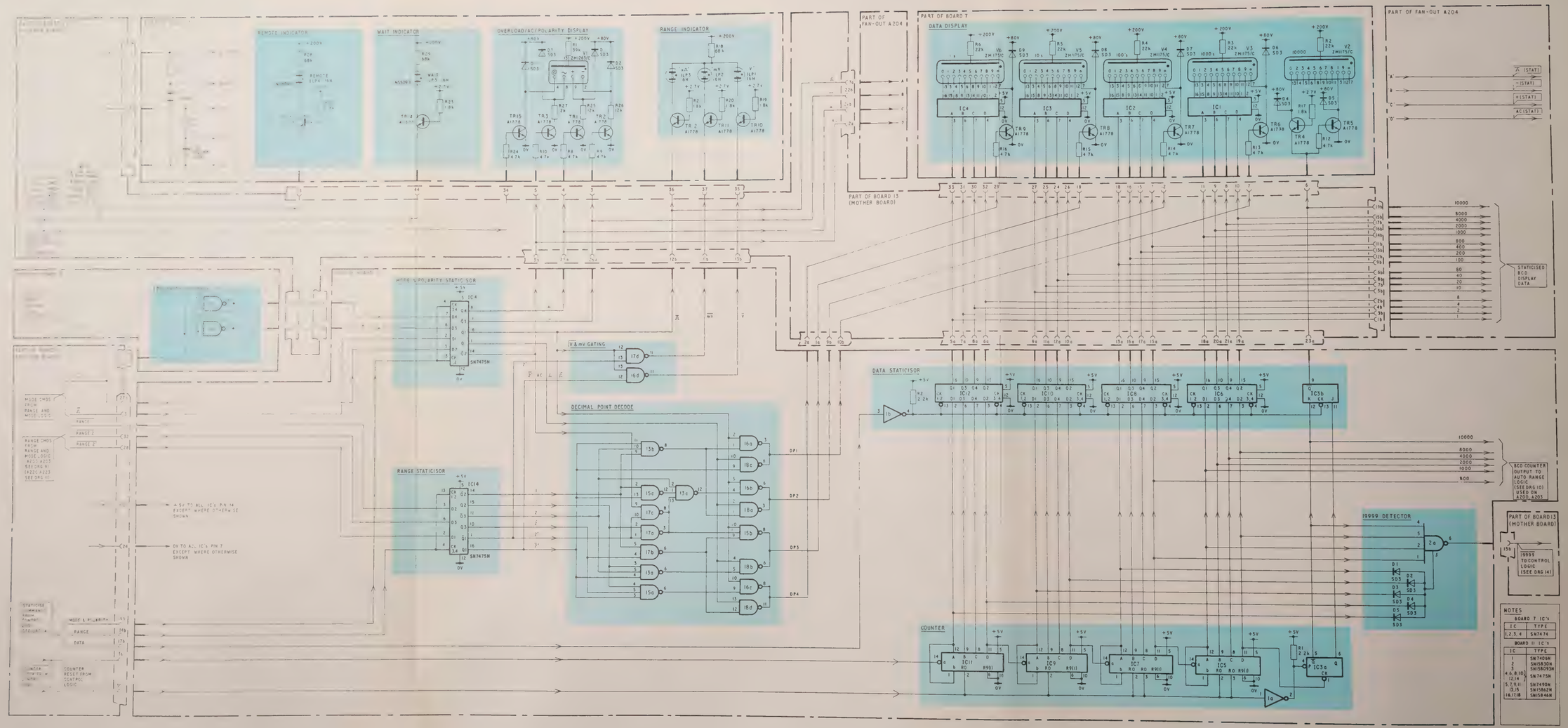



**Fig.7.99 Pcb's 7, 12 and 13**




**COUNTER & DISPLAY (NIXIE) CIRCUIT** **16a**

### 16b READOUT DISPLAY (7 SEGMENT)

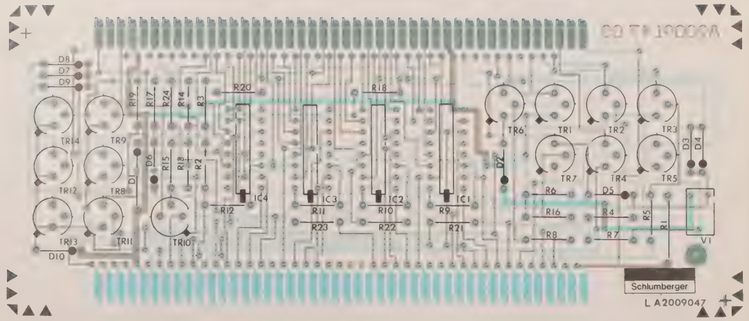
The output of the counter via the data staticiser, is converted to the 7 segment code necessary for display on indicators X1 and X2 by the decoder/drivers, IC's 1 to 4.

Each decoder/driver accepts the BCD information from the data staticiser (Board 11) and decodes it. The data are then used to drive the seven segments of the appropriate display without the need for other circuit elements.

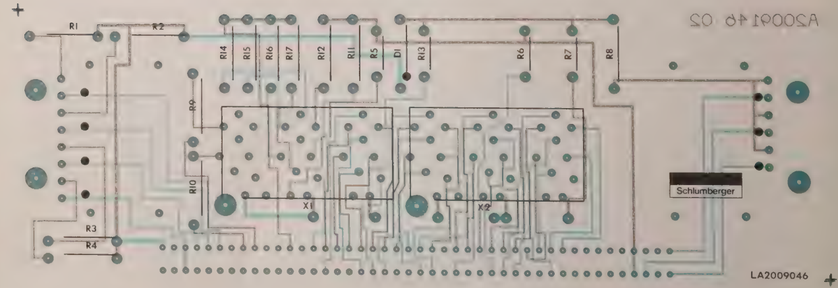
The brightness level of the display is determined by resistors R9 to R12, (Board 47) which control the programmed current level to the segments. To ensure even brightness of all segments, the output segment current of the decoder/driver is ratioed to the output of segment b. (with segment b = 1.00 then segments a, f and g = 0.93, c = 1.25, d = 1.00 and e = 1.10).

The decimal points of indicators X1 and X2 (the lower triangles) are driven from the decimal point decode circuit (Board 11). The upper triangles are "keep alive" cathodes which are used to ensure continuous ionisation of the indicators.

Diodes D3 to D5 protect transistors TR5 to TR7 by preventing the collector voltages from exceeding +88V.

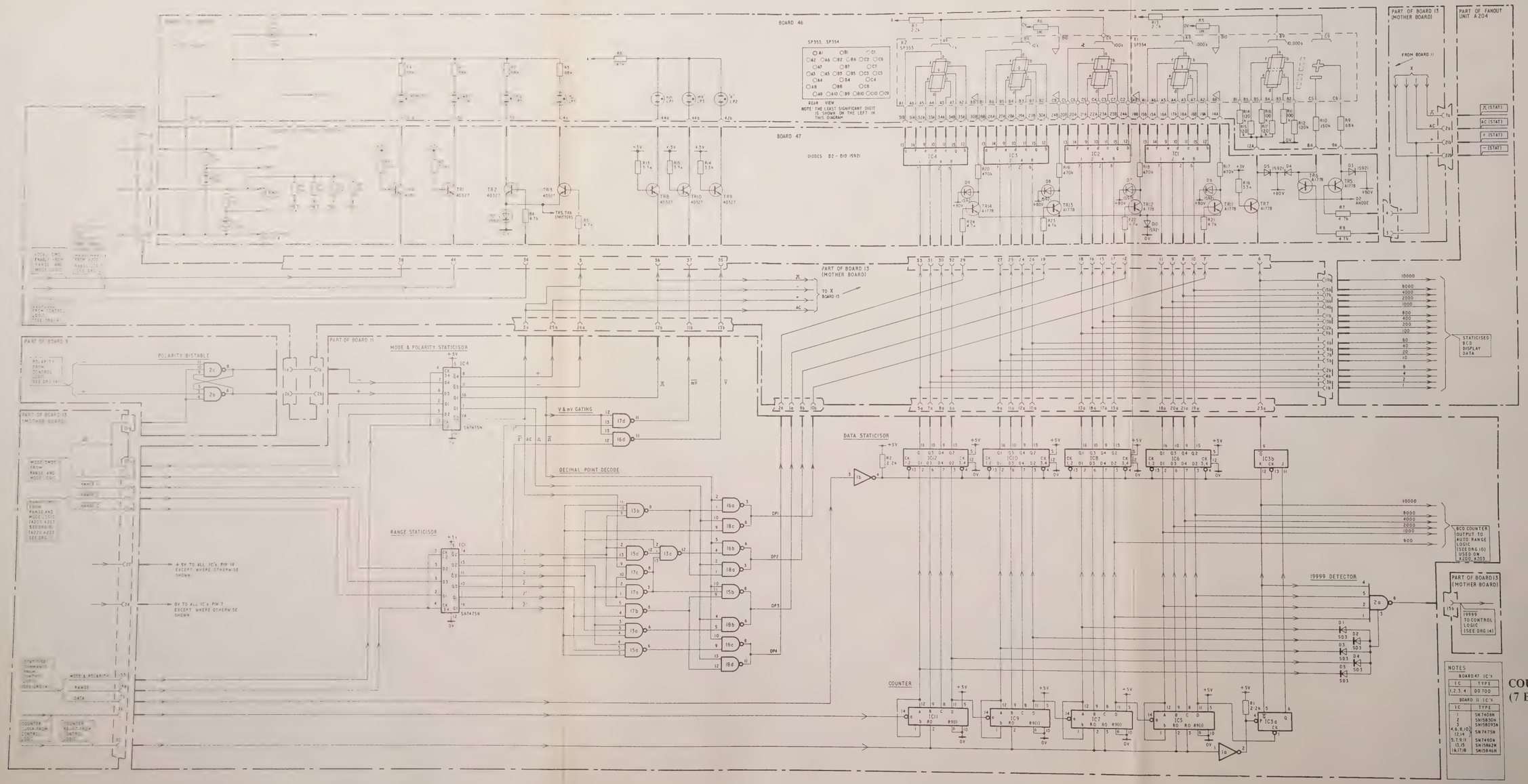



Component layout pcb No. 47




Component layout pcb No. 46

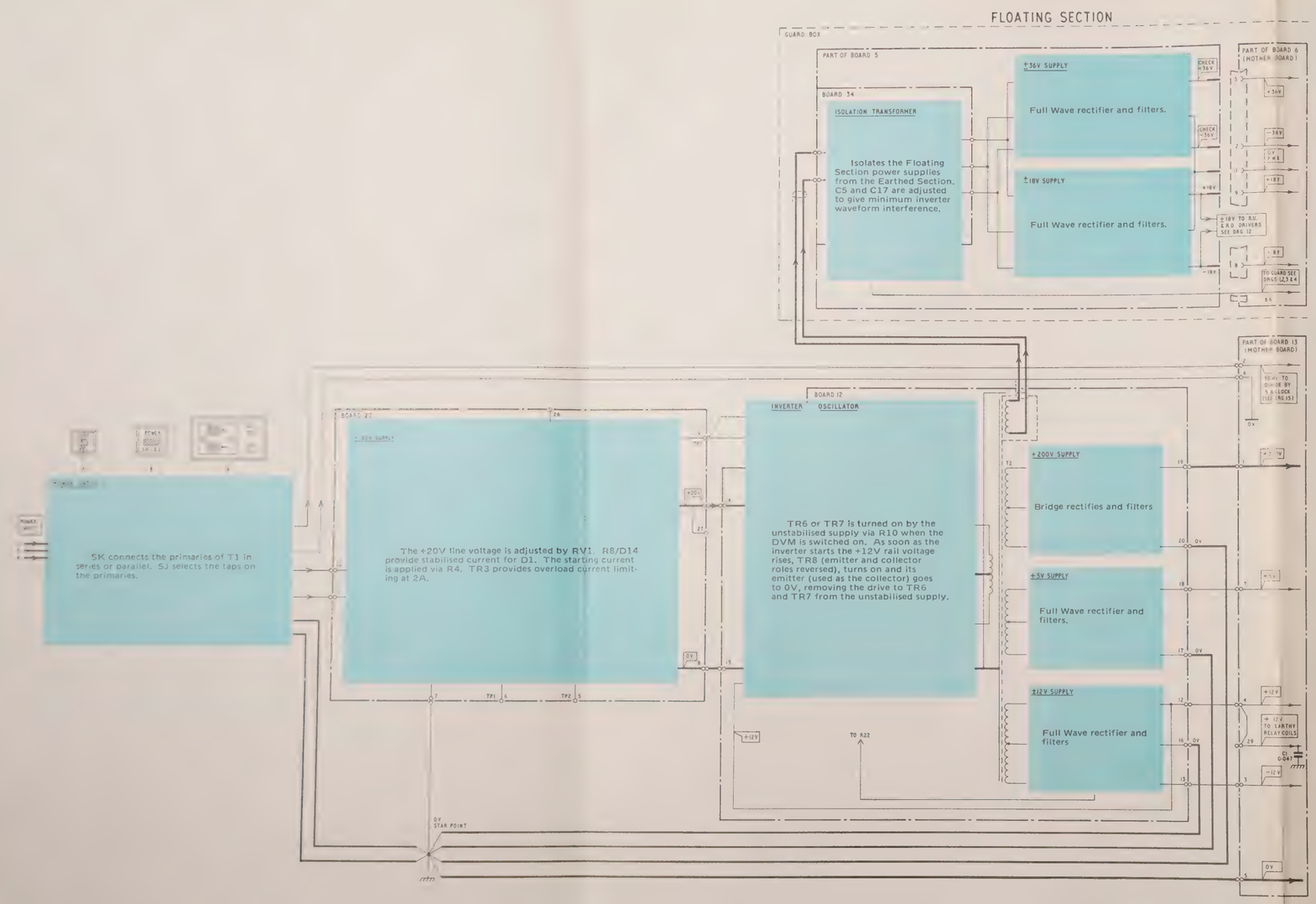
◄ Component layout pcb No. 47


BOARD 46
BOARD 47
SP353, SP354
REAR VIEW
NOTE THE LEAST SIGNIFICANT DIGIT IS SHOWN ON THE LEFT IN THIS DIAGRAM
DIODES D2 - D10 IS921
PART OF BOARD 13 (MOTHER BOARD)
PART OF FANOUT UNIT A204
FROM BOARD 11
A (STAT)
AC (STAT)
+ (STAT)
− (STAT)
TO X BOARD 15
STATICISED BCD DISPLAY DATA
PART OF BOARD 9
POLARITY BISTABLE
PART OF BOARD 11
MODE & POLARITY STATICISOR
V & mV GATING
DECIMAL POINT DECODE
RANGE STATICISOR
DATA STATICISOR
BCD COUNTER OUTPUT TO AUTO RANGE LOGIC (SEE DRG 10) USED ON A200, A203
19999 DETECTOR
19999 TO CONTROL LOGIC (SEE DRG 14)
COUNTER
+5V TO ALL IC's PIN 14 EXCEPT WHERE OTHERWISE SHOWN
0V TO ALL IC's PIN 7 EXCEPT WHERE OTHERWISE SHOWN
NOTES
BOARD 47 IC's
IC TYPE
1, 2, 3, 4 DD 700
BOARD 11 IC's
IC TYPE
1 SN 7404N
2 SN 5830N
3 SN 5809 3N
4, 6, 8, 10, 12, 14 SN 7475N
5, 7, 9, 11, 13, 15 SN 7490N
16, 17, 18 SN 5862N
SN 5846N

COUNTER & DISPLAY (7 BAR) CIRCUIT **16b**

JR/A200/2

7.16.8


FLOATING SECTION
GUARD BOX
PART OF BOARD 5
BOARD 34
ISOLATION TRANSFORMER
Isolates the Floating Section power supplies from the Earthed Section. C5 and C17 are adjusted to give minimum inverter waveform interference.
±36V SUPPLY
Full Wave rectifier and filters.
±18V SUPPLY
Full Wave rectifier and filters.
PART OF BOARD 6 (MOTHER BOARD)
PART OF BOARD 13 (MOTHER BOARD)
BOARD 22
+20V SUPPLY
The +20V line voltage is adjusted by RV1. R8/D14 provide stabilised current for D1. The starting current is applied via R4. TR3 provides overload current limiting at 2A.
BOARD 12
INVERTER OSCILLATOR
TR6 or TR7 is turned on by the unstabilised supply via R10 when the DVM is switched on. As soon as the inverter starts the +12V rail voltage rises, TR8 (emitter and collector roles reversed), turns on and its emitter (used as the collector) goes to 0V, removing the drive to TR6 and TR7 from the unstabilised supply.
+200V SUPPLY
Bridge rectifies and filters
+5V SUPPLY
Full Wave rectifier and filters.
±12V SUPPLY
Full Wave rectifier and filters
SK connects the primaries of T1 in series or parallel. SJ selects the taps on the primaries.
TO A22
0V STAR POINT

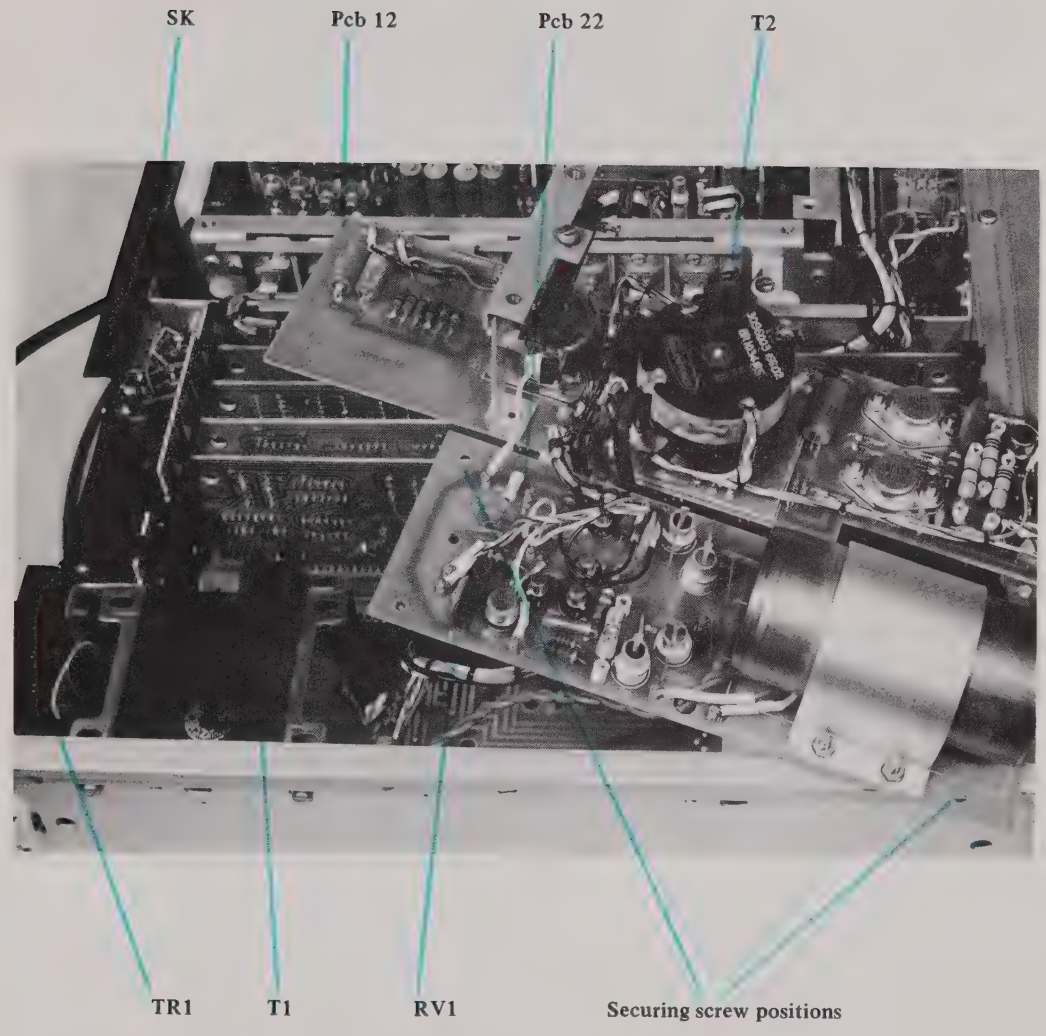



Fig.7.100 Removal of Earthy Power Supply

1) Remove the three screws on the left side chassis, securing Pcb 22.

2) Release Pcb 12 from the securing clips.

3) Pcb's 12 and 22 may then be eased from the main frame.

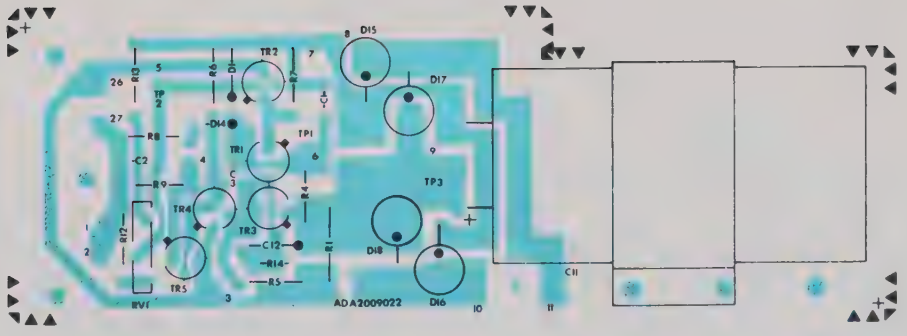



Fig.7.101 Pcb 22

**R1, R2, C1 and C2 (POWER INPUT) are located on a Tag Board, mounted below the Fan Out Socket Plate.**

**For access, remove the Dvm Bottom Panel.**

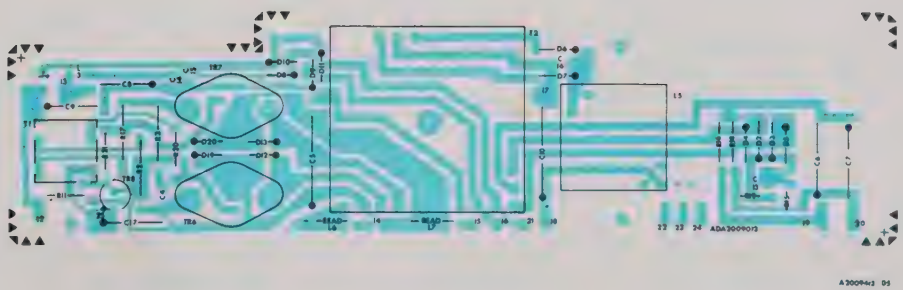


Fig.7.103 Pcb 12

Fig.7.105 Pcb 5

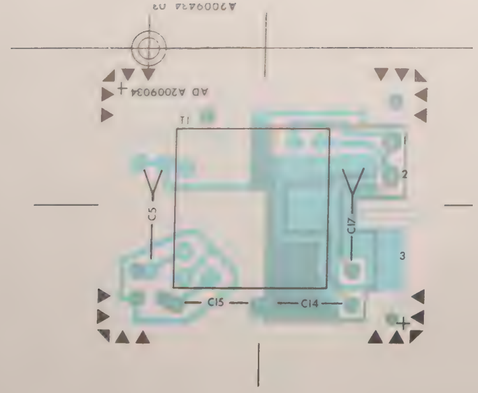
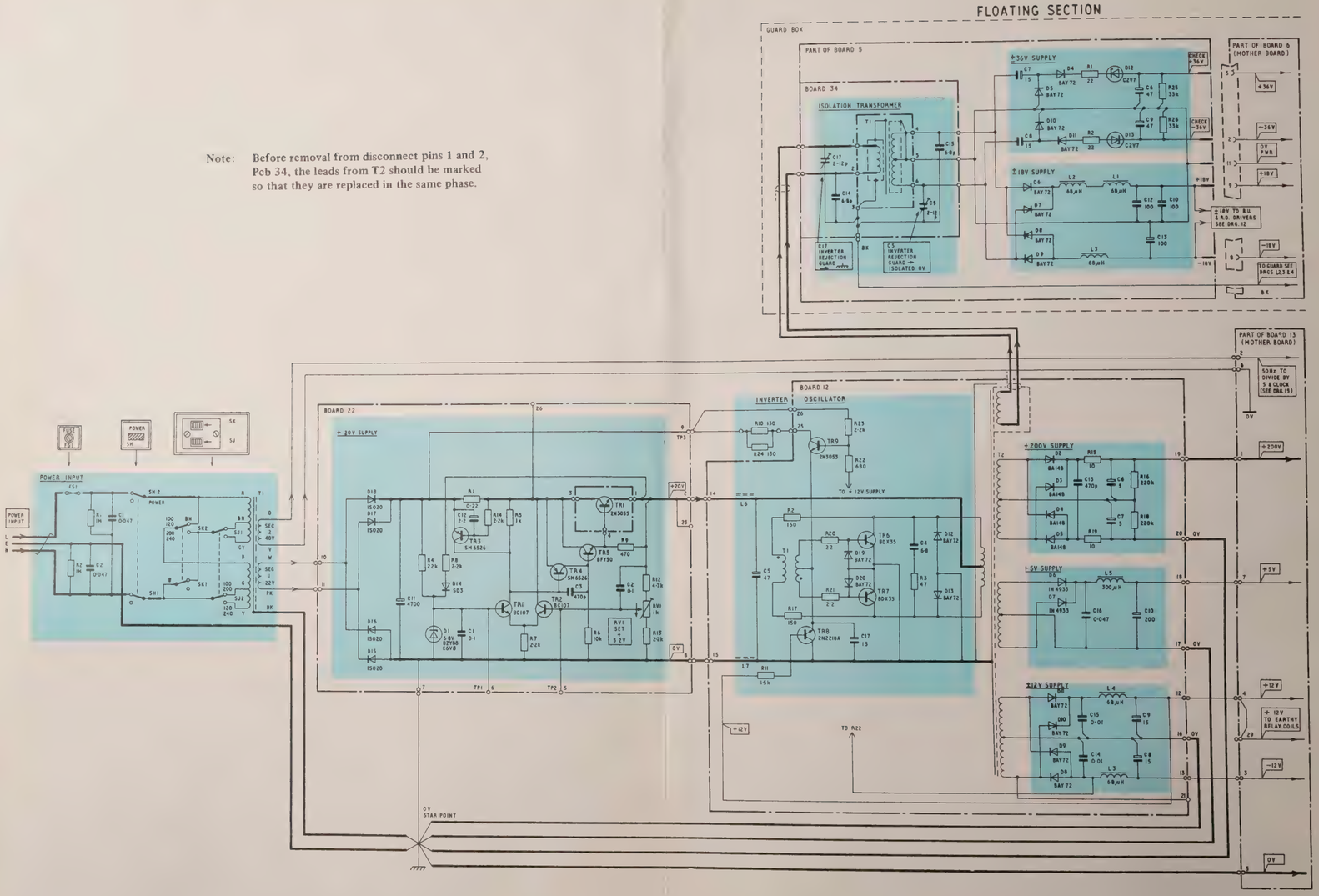



Fig.7.107 Pcb 34

Note: Before removal from disconnect pins 1 and 2, Pcb 34, the leads from T2 should be marked so that they are replaced in the same phase.



REMOTE SAMPLE CONTROL

Remote Sample:

A contact or pulse sample triggers monostable IC1, which has a period of 1ms if DATA IS CHANGED is low (is not changed) and 10ms if it is high (is changed). At the end of this period IC6a is clocked and REMOTE SAMPLE goes low initiating a sample. At the start of ramp up 10,SEC SAMPLE goes low and sets REMOTE SAMPLE high.

10/SEC Sample:

REMOTE SAMPLE is held high.

OVERLOAD STORE

If an OVERLOAD is present PRINT COMMAND (PULSE) clocks OVERLOAD high. OVERLOAD is reset low on receipt of a sample command.

PRINT COMMAND (LEVEL) GENERATOR

PRINT COMMAND (LEVEL) is set high by the input from Print Command (Pulse) Generator and is clocked low on receipt of a sample command.

PRINT COMMAND (PULSE) GENERATOR

8$\mu$s after the end of ramp down STATICISE DATA goes high and clocks PRINT COMMAND (PULSE) high. 18$\mu$s after the end of ramp down COUNTER CLOCK sets PRINT COMMAND (PULSE) low.

CLOCK SWITCH

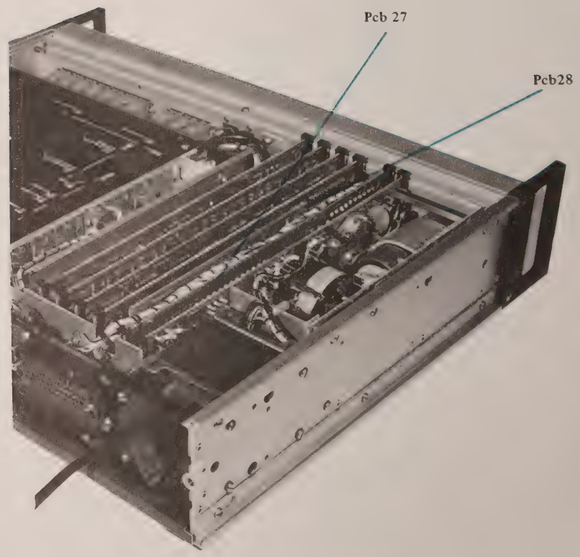
At switch-on RANGE COUNT goes low 8$\mu$s after the end of the first ramp down and sets IC5b Q output high, IC4c output low and IC5a $\overline{Q}$ output low.

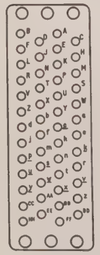
16$\mu$s after the end of ramp down RANGE COUNT goes high. At the start of ramp up COUNTER RESET goes low clocking IC5b Q output low. The next COUNTER RESET (16$\mu$s after the end of ramp up) clocks IC5b Q output high. Then the COUNTER CLOCK input clocks IC5a and its $\overline{Q}$ output goes high, gating the COUNTER CLOCK via IC4b.

At the end of ramp down COUNTER CLOCK stops for 18$\mu$s, during which time RANGE COUNT sets IC4a output low and IC5a output low.

NOTES
BOARD 28 IC's

| IC | TYPE |
|---|---|
| 1 | SN74121N |
| 2 | SN7407N |
| 3 | SN15836N |
| 4 | SN7400N |
| 5 | SN15B095N |
| 6,7 | SN7474N |
| 8 | SN7413N |



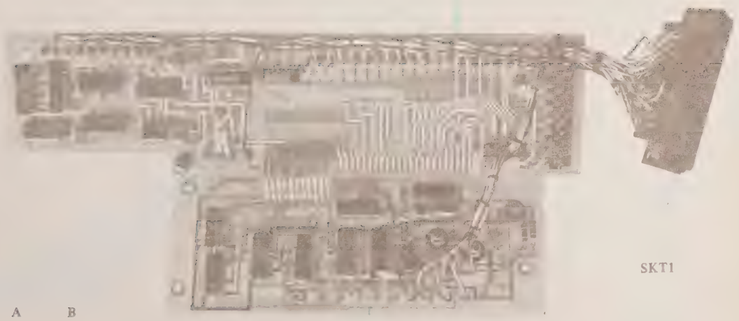
A204 Socket (SKT1) Notation

Fig.7.109 A204 Fan out Installation and Socket Notation

Pcb 27 fits the vacant Pcb 13 Socket, A2049127, see Fig.7.99. The 50-WAY Fan Out Socket (SKT1) fits in place of the rear panel Blanking Plate.

A204 FAN OUT
SHEET 1
DESCRIPTION

Pcb 27



SKT1

C A B

CODE Pins
(Linked for CODE 2)

Pcb 28

Fig.7.110 A204 Fan Out, Pcb's 27, 28 and Code Pins

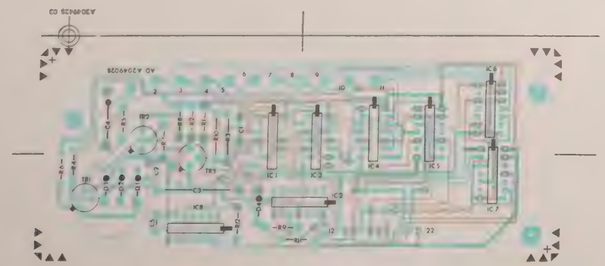
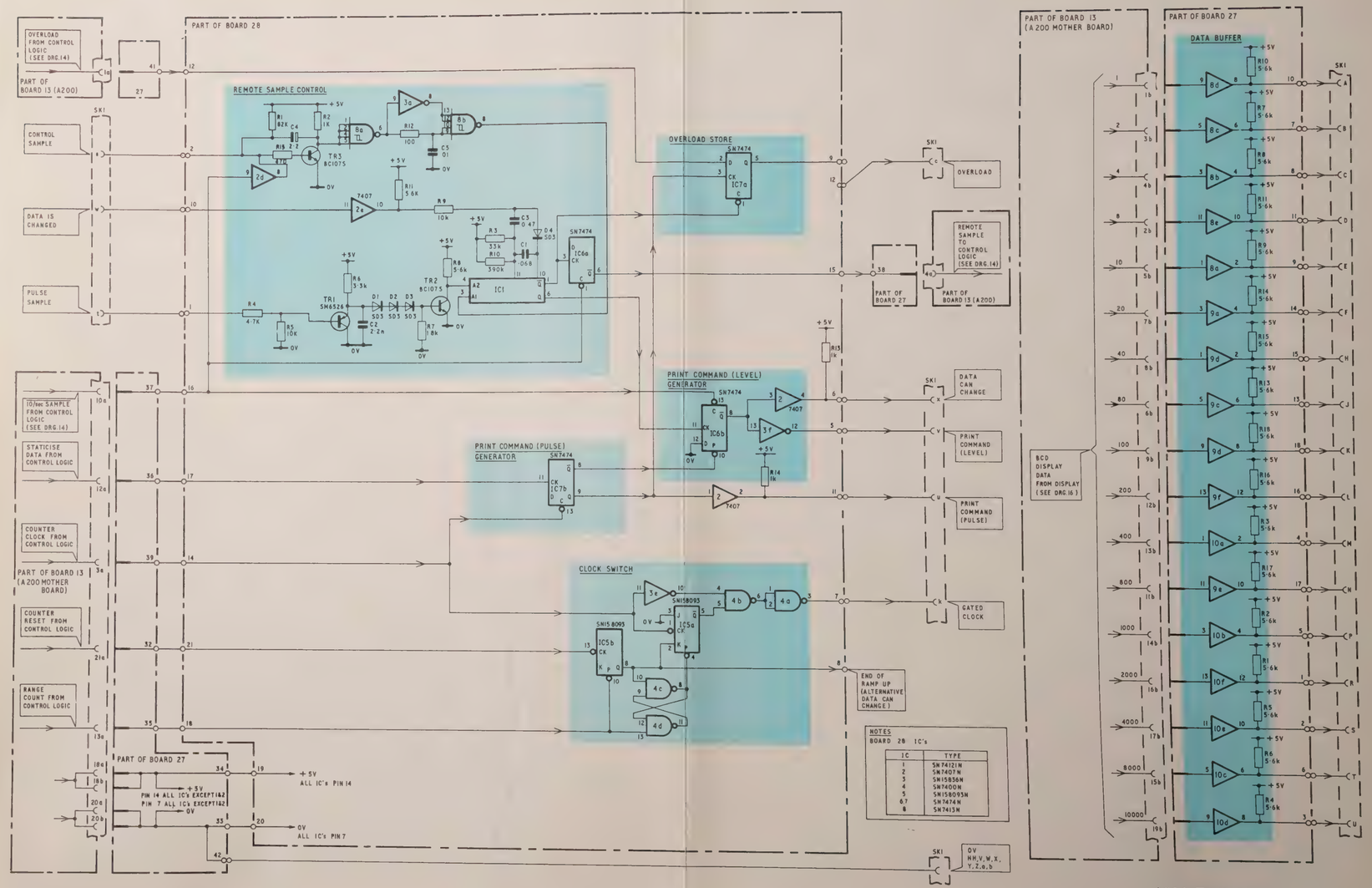
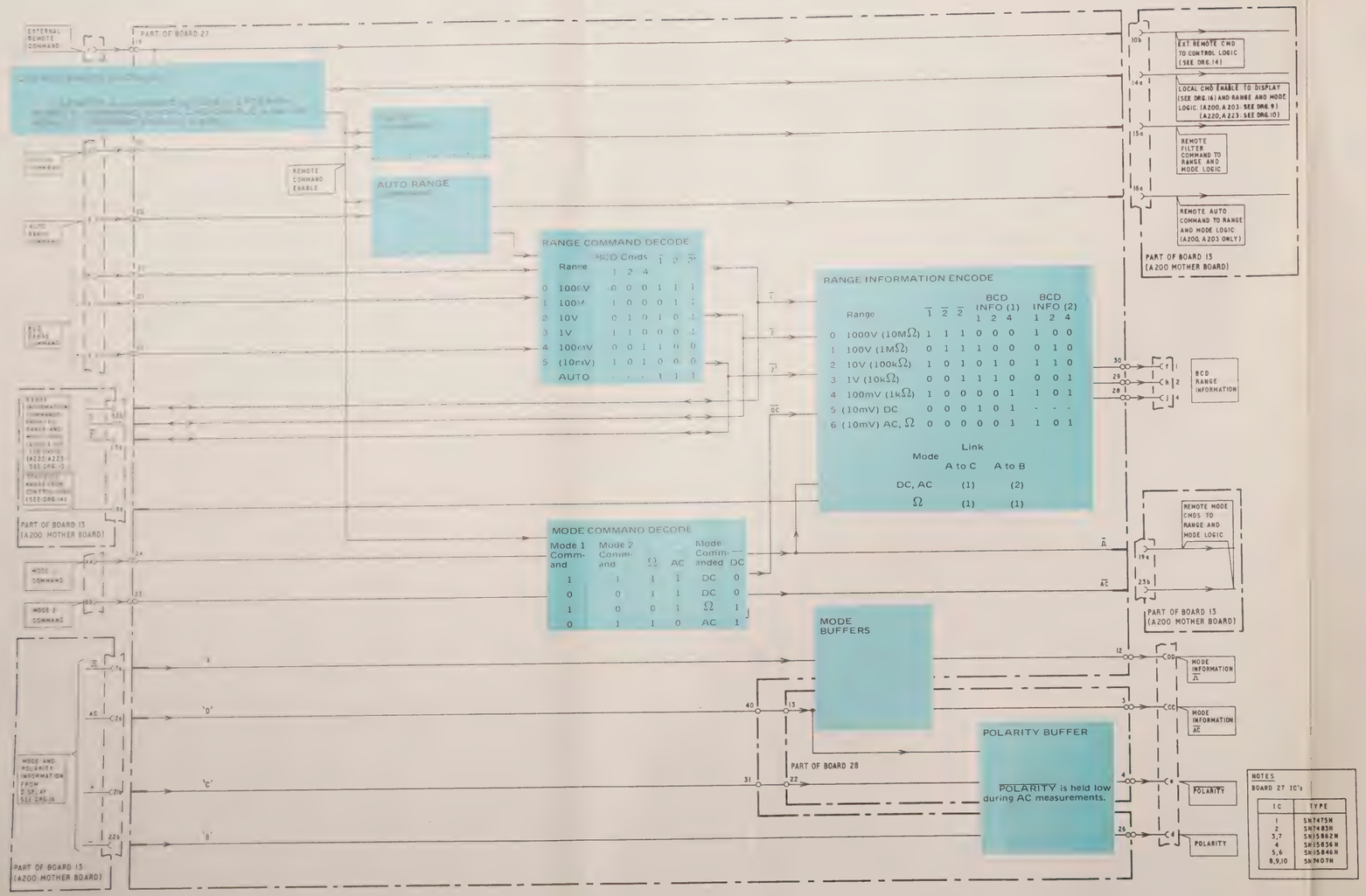


Fig.7.111 Pcb 28




A204 FAN OUT
SHEET 1
CIRCUIT



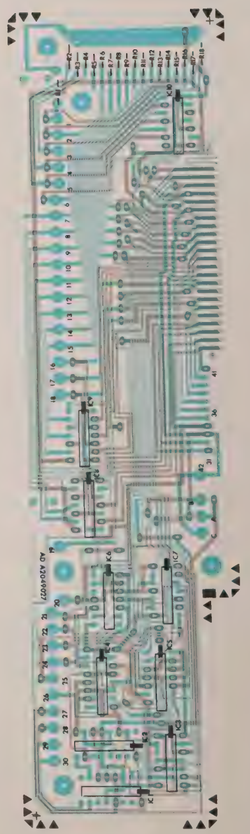



Fig.7.112 Pcb 27

A204 FAN OUT
SHEET 2
DESCRIPTION

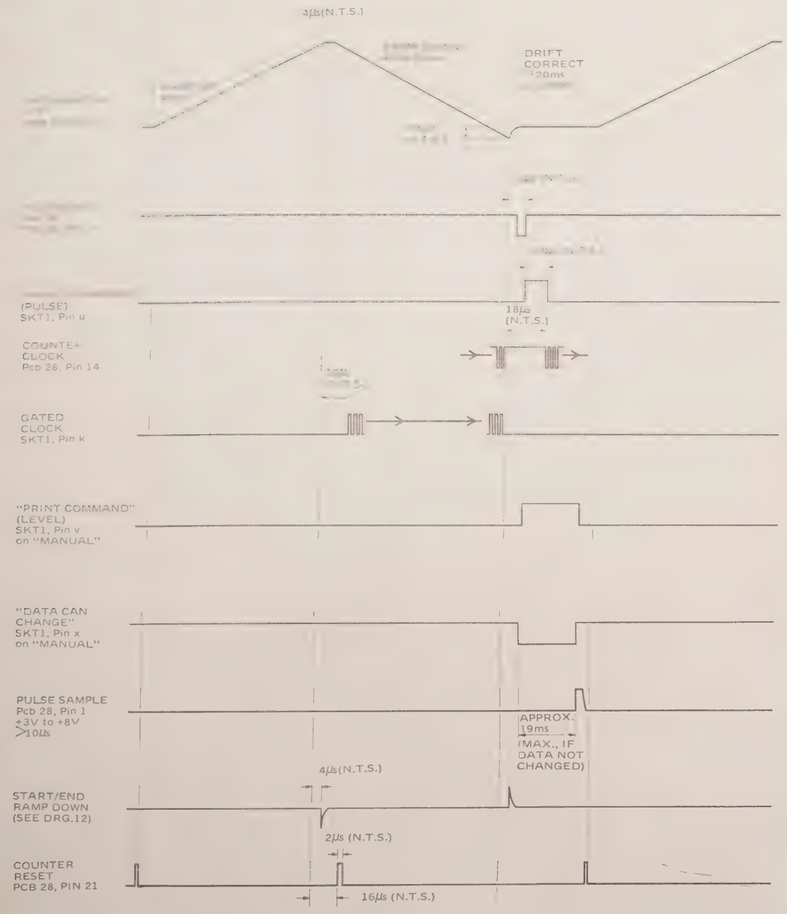
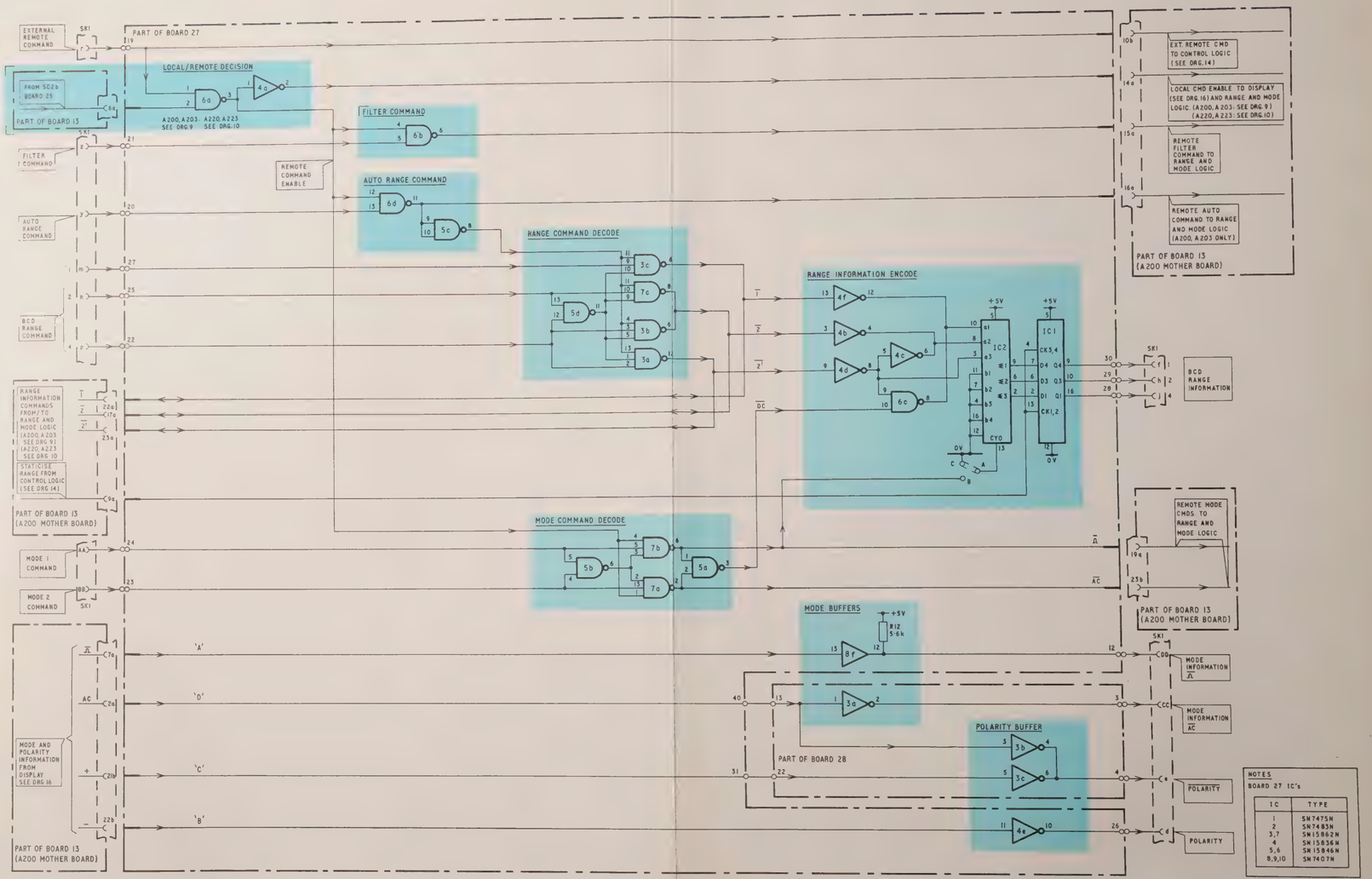

4μs(N.T.S.)
DRIFT CORRECT 20ms
(PULSE) SKT1, Pin u
18μs (N.T.S.)
COUNTER CLOCK Pcb 26, Pin 14
GATED CLOCK SKT1, Pin k
"PRINT COMMAND" (LEVEL) SKT1, Pin v on "MANUAL"
"DATA CAN CHANGE" SKT1, Pin x on "MANUAL"
PULSE SAMPLE Pcb 28, Pin 1 +3V to +8V >10μs
APPROX. 19ms (MAX., IF DATA NOT CHANGED)
4μs(N.T.S.)
START/END RAMP DOWN (SEE DRG.12)
2μs (N.T.S.)
COUNTER RESET PCB 28, PIN 21
16μs (N.T.S.)

Fig.7.113 A204 FAN OUT WAVEFORMS




A204 FAN OUT
SHEET 2
CIRCUIT

# SECTION 8 Test Specification

## CONTENTS


| | | Page |
|---|---|---|
| A | Initial Calibration | 8.2 |
| B | DC Final Calibration | 8.13 |
| C | AC and Ω Final Calibration (A203 and A223 only) | 8.15 |
| D | Testing The A204 Fan Out Unit | 8.18 |
| E | Appendix, Test Equipment | 8.24 |
| F | AC Calibration (A205/A225) | 8.28 |


**Multimeter**, 2% Grade, 20 000Ω/volt, e.g. AVO Model 8.

**Frequency Counter**, to 1MHz and 10ppm accuracy.

**Oscilloscope**, dc to 30MHz, e.g. Solartron A100.

**Thermocouple Thermometer**, 2% Grade, e.g. Comark 1621.

**D.C. Calibrator**, ± 0.003% accuracy, e.g. COHU 351

**A.C. Calibrator**, from ± 0.02% accuracy, e.g. Hewlett Packard 745A with Hewlett Packard 746A

**Pulse Generator**, up to 200kHz, 20ns rise time, e.g. Solartron 1101.2

**EX 3193 Connector**, 3 way Input Lead (Solartron).

**Kelvin Varley Divider**, 10kΩ, 5ppm grade, e.g. ESI Dekavider RV622A.

**Decade Resistance Standard**, 0.005% grade, e.g. ESI RS624.

**Standard Resistors**,

| | | |
|---|---|---|
| 9 x 2MΩ, | 0.1%* | |
| 1.8MΩ, | 0.01%* | * Known uncertainty. |
| 180kΩ, 18kΩ, 1.8kΩ, | 0.003%* | |

### Precautions

Short circuits either across power rails or from power rails to ground (0V) will blow the fuse. If the Inverter Oscillator stops switch OFF and then ON.

Check for short circuits on the rails.

Check the connections from inverter board (pcb 12) to the earthy mother board (pcb 13) of the rails. (See Drg. 17).

Remove pcb 2 from the floating section.

For the purpose of test and calibration Model A227 is identical to the A220.

For Models A205 and A225 see section F on page 8.28.

## A. INITIAL CALIBRATION

### 1. POWER SUPPLIES

1.1 Switch OFF.
Set mains voltage selector to 220 - 255V rms.
Check that a 250mA (300mA)* fuse is fitted.
Connect the DVM to the mains via a variac.
Set the variac to 230V rms and switch ON.

1.2 Measure the voltage on pin 18 of pcb 12 with respect to 0V.
Adjust RV1 on pcb 22 to obtain a reading of +5.2V ± 0.1V.

1.3 Increase the variac output to 250V and check that the +5V rail voltage remains constant.

1.4 Switch OFF.
Set the mains voltage selector to 195 - 230V rms.
Reduce the variac output to 200V rms.
Switch ON.
Check the 5V rail voltage is +5.2V ± 0.1V

1.5 Repeat 1.4 with the mains voltage selector set to 98-115V and the variac output set to about 100V rms and a 500mA (750mA)* fuse fitted.

1.6 Repeat 1.5 with the mains voltage selector set to 100-128V and the variac output set to about 115V rms.

1.7 Switch OFF.
Reset the mains voltage selector to 220-255V and the variac to 230V rms and fit a 250mA (300mA)* fuse. Fit the 220-255V mains selector plate.

1.8 Switch ON.
Check the +36V and -36V rails in the floating section.

1.9 Switch OFF.
Fit pcb 2 and switch ON.

* As indicated on MAINS SELECTOR PLATE

### 2. CLOCK OSCILLATOR

| NOTE | Pcb 8 | 50Hz | 60Hz |
|---|---|---|---|
| *A200, A203 only | C8 | 150p | 100p |
| | C6* | 18p | 10p |

2.1 (A200, A203)
Short circuit C3 on pcb 8.
Switch ON.
Adjust T1 on pcb 8 to give a 500kHz (600kHz from 60Hz mains supply) square wave signal at the output of IC1e (TP1). (See Drg. 15).

### 3. BASIC OPERATION

3.1 Switch ON.
Switch to DC, 10/SEC. FAST.
Short circuit the High and Low input terminals.
Switch to each range in succession and check that the decimal points, V and mV signs are clear and correct.

3.2 Switch to AC. (A203, A223)
Repeat 3.1 (10mV range is the same as 100mV.)
Check that the AC sign appears clearly.

3.3 Switch to Ω . (A203, A223)
Check that the kΩ sign appears.
Switch to each range in succession and check that the decimal points appear correctly.
(10mV range is the same as 1kΩ ).

3.4 A200/A203 only.
Switch to 1000V DC range.
Apply approximately +1mV to the input.
Switch to AUTO range.
Check that the reading is approximately correct.
Increase the input to obtain more than 19000 digits.
Check that the range changes to 100mV.
Decrease the input to less than 1800 digits.
Check that the range changes back to 10mV.

3.5 Switch to DC and the 10V range.
Apply approximately +1V to the inputs.
Check that the polarity sign is clear and correct.
Reverse the polarity of the input.
Check that the polarity sign is clear and correct.

3.6 Switch to MANUAL sample. Vary the applied input.
Check that the reading remains unchanged, (including polarity).
Operate MANUAL sample once.
Check that the new reading is now obtained. (Polarity signs, decimal points, V and mV all changed only after initiating the sample).
Apply 100mV input on the 10mV range.
Check that the overload sign appears without sampling.

3.7 A200/A203 only.
Switch to SLOW filter, 10V range, MANUAL.
Apply approximately +1V to the input.
Operate MANUAL sample once.
Check that the WAIT sign appears for about 1s before the new range is displayed.
Switch to AUTO range.
Operate MANUAL sample once.
Check that the WAIT sign appears (may be flashing) until the correct reading is staticised.

## 4. INPUT AMPLIFIER (pcb 2)

NOTE: A200/A203 TR1 and TR3 are selected for $< 0.3\ \mu V$ rms noise using TG 1030 (see APPENDIX).

4.1 A200/A203 only. (See Drg. 6)
Switch OFF.
Short circuit the High and Low input terminals.
Short circuit the junction of R1 and C1 to 0V.
Switch to DC.
Connect a source of 10mV between the junction of R1 and R11 and 0V.
Connect an oscilloscope set to 5mV/cm to T.P.I.
Switch ON.
Adjust RV2 to obtain a maximum amplitude square waveform.
Remove the input and the short circuit.

4.2 A200/A203 only.
Measure the voltage across C9.
If the voltage exceeds 1.8V, cut the link across R50.

4.3 Fit Amplifier Screen.

4.4 Switch to 10/SEC. DC, SLOW filter, 10mV range. (100mV range on A220/A223).
Connect 1MΩ in parallel with 1μF across the input terminals.
Adjust RV1 for minimum input current, (less then 20μV reading i.e. $2 \times 10^{-11}$A).

## 5. INTEGRATOR (pcb 3, see Drg. 12)

5.1 Insert a thermocouple probe into the holes provided in the oven heat sink.
Carefully adjust RV1 to obtain a temperature of $77 \pm 1^{o}$C, using the Thermocouple Thermometer; clockwise increases temperature. The adjustment is fairly critical; allow time for the reading to settle. *This is not done on later models where RV1 is ommitted.*

(Note: Remove pcb 2, or use Extension Board A2009033 for access to RV1)

5.2 Reference Adjustment.
Switch to 10V range, FAST filter, DC.
Connect input leads to a voltage source. (e.g. COHU 351 set to +10.0000V and RV622A).
Apply an input of 5.651V. (Set RV622A to 5,6,5,1,0,0).
Note the reading.
Using table 1, cut the appropriate links and also the link by the side joining pin 11 to TR3 (See Drg. 5).

**Table 1**

| Reading Between | Cut Link Across | | | | |
|---|---|---|---|---|---|
| | R46 | R45 | R44 | R43 | R42 |
| 19.2976------19.1556 | * | * | * | * | * |
| 19.2206------19.0854 | * | * | * | * | - |
| 19.1506------19.0213 | * | * | * | - | * |
| 19.0867------18.9626 | * | * | * | - | - |
| 19.0281------18.9087 | * | * | - | * | * |
| 18.9743------18.8590 | * | * | - | * | - |
| 18.9245------18.8130 | * | * | - | - | * |
| 18.8785------18.7703 | * | * | - | - | - |
| 18.8084------18.6699 | * | - | * | * | - |
| 18.7414------18.6086 | * | - | * | - | * |
| 18.6802------18.5525 | * | - | * | - | - |
| 18.6241------ 18.5009 | * | - | - | * | * |
| 18.5725------18.4533 | * | - | - | * | - |
| 18.5248------18.4092 | * | - | - | - | * |
| 18.4807------18.3683 | * | - | - | - | - |
| 18.4135------18.2722 | - | * | * | * | - |
| 18.3493------18.2135 | - | * | * | - | * |
| 18.2906------18.1597 | - | * | * | - | - |
| 18.2368------18.1102 | - | * | - | * | * |
| 18.1873------18.0646 | - | * | - | * | - |
| 18.1416------18.0224 | - | * | - | - | * |
| 18.0993------17.9832 | - | * | - | - | - |
| 18.0349------17.8911 | - | - | * | * | - |
| 17.9732------17.8348 | - | - | * | - | * |
| 17.9169------17.7832 | - | - | * | - | - |
| 17.8653------17.7357 | - | - | - | * | * |
| 17.8178------17.6920 | - | - | - | * | - |
| 17.7740------17.6515 | - | - | - | - | * |
| 17.7333------17.6139 | - | - | - | - | - |

* = Cut Link

5.3 Set the standard voltage source to +10.0005V.
Adjust RV5 **(Drg.5)** to obtain a flicker between +10.000 and +10.001.
Change the polarity of the input.
Adjust RV4 **(Drg. 12)** to obtain a flicker between -10.000 and -10.001.

5.4 Offsets.
Switch to DC.
Apply an input of +10.5mV from the voltage source.
Adjust RV2 to obtain a flicker between +10 and +11 digits.
Reverse the polarity of the input.
Adjust RV3 to obtain a flicker between -10 and -11.

5.5 Repeat 5.3 and 5.4 until no further adjustment of RV2 and RV3 is necessary.

5.6 Reduce input to zero.
Check that the reading is ± 00.000V, (polarity sign flickers).
Increase the input in - 0.1mV steps to - 0.3mV.
Check that the instrument displays - 00.000V.
(Note: R29 on pcb 3 is selected in test for correct zero reading, its value being 10kΩ, 12kΩ or 15kΩ).
Apply an input of +10.000V using a divider box. Reduce the divider box ratio in 1% steps and check that the reading is correct to within 1 digit.
Repeat for opposite polarity.
Also check that the numbers are clearly displayed in all the windows.

## 6. FLOATING SECTION

If boards have been disturbed reposition them carefully and fit the top cover.

6.1 Switch to DC.
Set the μV OFFSET to the centre of its swing.

6.2
a) Connect a 10kΩ resistor between Low and mains earth.
Short circuit High to Low.
Connect an oscilloscope probe to the Guard Box.
Adjust C17 on pcb 34 (See Drg. 17) to obtain minimum 25kHz spike waveform, (approximate amplitude 10mV).

b) Remove the oscilloscope probe from the Guard Box and connect to 0V Pwr (pin 30, pcb 6), connecting oscilloscope low to Guard Box.

Adjust C5 pcb 34 for minimum 25kHz spikes (approximately 10mV).

(Note: On the A203 and A223, C5 may be set for zero reading on the 1MΩ and 10MΩ Ranges, FAST filter.

c) Select 10mV range, FAST filter (100mV Range on the A220). Short the input leads together and connect them to the Pulse Generator via a 1MΩ resistor.

Set the Pulse Generator to square wave, 3.5Hz and 30V amplitude.

Adjust C6 pcb 26 (see Drg. 5) for optimum common mode rejection (minimum scatter on the dvm reading).

On the A220 and A223, set C6 half way if no scatter is observed.

Ensure that C6 lead (Black) to mains earth is dressed for shortest length inside the Guard Box.

6.3 Switch to 10mV range and SLOW filter. (100mV range on A220/A223).
Note the reading.
Switch to FAST filter.
Adjust RV2 on pcb 6 to obtain the same reading as above, making the appropriate link on the back of pcb 6 (See Drg. 5).
Repeat until they are the same, (with fast and slow filter).

6.4 Switch to SLOW filter.
Adjust the μV OFFSET pot. to obtain ± 00.000mV.
Check that the μV OFFSET pot. covers more than 10 digits on either side of zero. (5 digits on A220 and A223).
Reset zero.
Check that the instrument reads zero on all ranges with either filter.

## 7. RANGE CALIBRATION

Switch to DC.

Apply input voltages as shown below and adjust corresponding pots. to obtain the reading given. (If a source of more than 10V is not available, use 10.000V on 10V range).

| Test | Range | Filter | Input | Adjust | pcb | Drawing | Reading | ± |
|---|---|---|---|---|---|---|---|---|
| 7.1 | 10V | FAST | +18.0005V | RV5 | 3 | 5 | +18.000/1 | |
| | | | - 18.0005V | RV4 | 3 | 12 | - 18.000/1 | |
| *7.2 | 10mV | SLOW | +18.000mV** | RV3 | 26 | 5 | +18.000 | 3 |
| | | | - 18.000mV** | | | | - 18.000 | 3 |
| | 10mV | FAST | +18.000mV | | | | +18.000 | 4 |
| | | | - 18.000mV | | | | - 18.000 | 4 |
| 7.3 | 100mV | | +180.00mV | RV2 | 26 | 5 | +180.00 | 2 |
| | | | - 180.00mV | | | | - 180.00 | 2 |
| 7.4 | 1V | | +1.8000V | RV1 | 26 | 5 | +1.8000 | 1 |
| | | | - 1.8000V | | | | - 1.8000 | 1 |
| 7.5 | 100V | | +180.00V | RV1 | 6 | 1 & 2 | +180.00 | 1 |
| | | | - 180.00V | | | | - 180.00 | 1 |
| 7.6 | 1000V | | +1200.0V | | | | +1200.0 | 1 |
| | | | - 1200.0V | | | | - 1200.0 | 1 |

* A200/A203 only

** Mean reading to be 18000

## 8. INPUT IMPEDANCE

8.1 Switch to 10V range, FAST filter and DC.

Apply an input signal directly to the input terminals to obtain a 10.000V reading.

Reapply the same input via 1MΩ in parallel with 1μF.

The change in reading should be less than 1 digit.

Repeat with the SLOW filter.

The change in reading should be less than 1 digit.

8.2 Repeat 8.1 on the 1V range with an input of 18000 digits.

The change in reading should be less than 2 digits.

8.3 Repeat 8.1 on the 100mV range with an input of 18000 digits.

The change in reading should be less than 12 digits.

Repeat on opposite polarity.

The change in reading should be less than 12 digits.

The average of the two readings should be less than 2 digits.

## 9. NOISE LEVEL (A200/A203 only)

9.1 Switch to 10mV range, FAST filter and DC.

Apply an input of approximatley 10μV.

The indicated reading should not jitter by more than 2μV, (i.e. 4 digits).

9.2 Switch to SLOW filter.

The indicated reading should not jitter by more than 1μV, (i.e. 3 digits).

With adjustment of the μV OFFSET pot. of ½ bit it should be possible to obtain a flicker of 2 digits.

## 10. AC AND Ω FUNCTIONS (A203, A223).

Set up as in Section C.

## 11. REMOTE

Plug in an A204 Fan Out Unit.

Check that the instrument functions normally.

11.1 Switch to REMOTE.

Check that the REMOTE signal is illuminated.

11.2 Check that the instrument will not operate on any of the front panel controls except MANUAL sample, 10/SEC and POWER.

11.3 Connect the testgear TG1022/17 to the fan out socket, (if available, see APPENDIX).

Check that the instrument samples with contact sample, (or that it samples when pin s is connected to pin HH (0V).

11.4 Switch to REMOTE on TG1022/17, (or connect pin r to pin HH (0V).

Check that this operation disables all front panel controls except POWER.

Operate sample on TG1022/17 and check that the instrument samples, (or apply a Pulse Sample Command, positive pulse of amplitude between 3 and 8V and greater than 10$\mu$s wide) to pin t.

11.5 Switch to LOCAL and 10mV range on TG1022/17, (or command the 10mV as per the Operating Manual, and disconnect pin r from pin HH.)

Switch to 10/SEC. on the front panel.

Apply 10mV to the input.

Check that the instrument reads 10mV on the 10mV range.

Repeat on each range with an appropriate input, (or command each range as per the Operating Manual).

11.6 Switch to AUTO on TG1022/17. (A200/A203 only , or command AUTO as per the Operating Manual).

Apply 18mV to input.

Check that the instrument reads 18mV on the 10mV range.

Increase the input to more than 19mV. (19000 digits).

Check that the instrument changes range to 100mV.

Reduce the input to less than 18mV. (1800 digits).

Check that the instrument changes range to 10mV.

11.7 Switch to AC mode on TG1022/17, (A203/A223 only , or command AC as per the Operating Manual).

Check that the AC sign appears. Switch to each range in succession and check that the correct ranges are called, ( or command each range as per the Operating Manual).

11.8 Repeat for the $\Omega$ mode.

11.9 *Filter Settling Time, DC*

Switch OFF. Connect the test gear TG1022/19 (see APPENDIX) to the FAN OUT socket.

D.C. TEST.

Switch to DC, 10V range, Manual, SLOW filter. Switch ON.

Switch the test gear to 'RESPONSE' 1 SEC. TEST switch UP. Connect the DVM to the output of the test gear. Apply an input of 10.000V dc to the input of the test gear. Switch to TEST on test gear and check the reading is within ± 1 digit.

## 12. SERIES MODE REJECTION. COMMON MODE REJECTION. OVERLOAD

These tests are carried out using test Gear TG1022/18 (See APPENDIX). Use an EX3193 (3 terminal Input Connector) for LOW to GUARD leakage. Information on TG1022/18:

a) A switch to select three different AC signal ranges giving an FSD of 100mV, 5V, 100V r.m.s. This signal is indicated on the AC meter.

b) A variac to vary the AC signal on the above ranges.

c) A Pot. to vary the DC output signal from 0 to 500V FSD. This signal appears on the output terminals on the DC common mode, DC LO to GU Leakage and overload checks only.

d) A Pot. to vary the DC signal from a battery. This is used in series and AC common mode checks only.

e) A push button to check the battery voltage. This voltage is indicated on the DC meter (20V FSD).

f) A toggle switch to measure the current drawn by DVM on overload checks, when switched to mA the reading is indicated on the DC meter. On 500V the DC meter indicates the DC output voltage.

g) A switch to select the different tests to be done.

Figs. 8.1 to 8.3 show the basic test equipment, without external phase shift.
In this case SLOW response should be selected.

On overload checks, the test gear is connected as a voltage source. The output is varied by DC Variac 1. Alternatively the COHU 351 may be used.

Set the test gear TG1022/18 as follows:

Volts-current switch to volts.
DC high voltage pot fully anticlockwise
AC signal variac fully anticlockwise.

12.1 Series mode rejection:

a) Switch the DVM to DC, 10V range, 10/Sec, FAST filter.

Switch the test gear to 'Series Mode Rejection,' AC signal range to 5V on T.G. (100mV range on TG for A220 and A223) and also $90^{O}$ phase shift.

Switch ON both test gear and DVM.

Adjust DC signal pots "C" and "F" to obtain 10/1 digits.
Increase the AC signal until the indicated reading changes by 1 digit.
The reading on the AC meter should be greater than 2.3V r.m.s. (70mV for A220 and A223).
Reduce the AC signal to zero.

b) Switch to 10V range on DVM, and SLOW filter.
Switch the AC signal range to 100V (5V range for A/220 and A223 on test gear) also $0^{O}$ phase shift.

Adjust the DC signal pots "C" and "F" to obtain 10/1 digits.
Increase the AC signal until the indicated reading changes by 1 digit.
The reading on the AC meter should be greater than 70V r.m.s. (2.3V for A/220)
Reduce the AC signal to zero.
See fig. 8.1 for basic test.

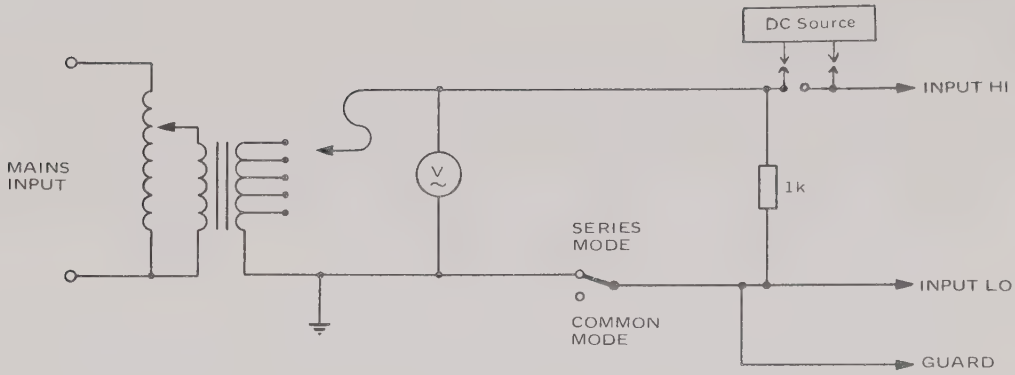



Fig. 8.1

12.2 AC common mode rejection.

a) Switch the test gear to "AC Common Mode Rejection" and the AC signal to 100V range.
Switch to 100mV range, FAST filter on DVM.

Adjust the DC signal pots "C" and "F" obtain 10/1 digits. Increase the AC signal until the indicated reading changes by 1 digit. The reading on the AC meter should be greater than 70V r.m.s. (1.5V for A/220).
Reduce the AC signal to zero.

b) Switch to AC mode, 1V range, SLOW filter on DVM.
Increase the AC signal to 100V rms.
The reading on the DVM should be less than 1,000 digits.
Reduce the AC signal to zero.
See Fig. 8.1 for basic test.

12.3 DC common mode leakage.

a) Switch to DC mode 100mV range SLOW filter on DVM.
Switch to 'HI/GND LEAKAGE' on the test gear. Increase the DC (VARIAC 1) pot to obtain 500V on DC meter. The displayed reading on the DVM should not exceed 56mV
Reduce the DC signal to zero.
See Fig. 8.2 for basic test.

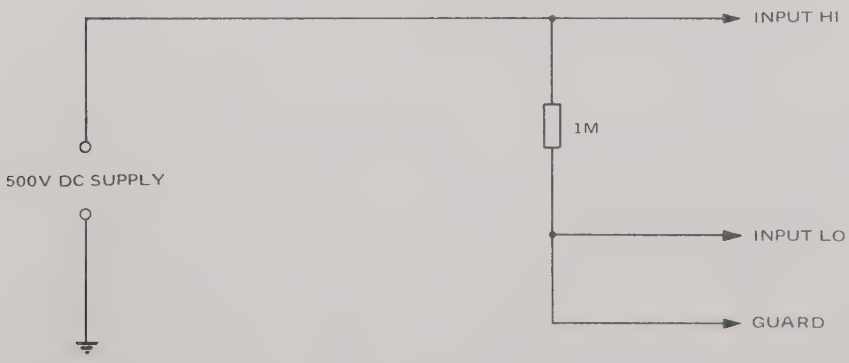



Fig. 8.2

(b) Switch to AC, 100mV range Slow filter on DVM.
Increase the DC (Variac 1) pot to obtain 500V on DC meter. The displayed reading on the DVM should not exceed 50mV.
Reduce the DC signal to zero.

12.4 LO to GUARD leakage.
Connect an EX 3193 in place of the standard input lead.
Switch to DC, 1V range SLOW filter on DVM.
Switch to "LO/GND LEAKAGE" on the test gear. Increase the DC (VARIAC 1) to obtain 500V on DC meter. The displayed reading on the DVM should not exceed 200mV. Reduce the DC signal to zero.
See Fig. 8.3 for basic test.

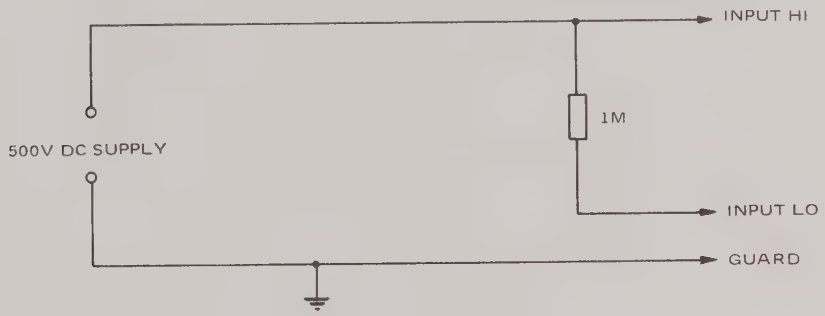



Fig. 8.3

12.5 Overload checks.
Alternatively, use COHU 351 as a DC source.

(a) Switch to 10mV range on DVM (100mV on A220 and A223).
Switch to "+ve O/L" on test gear. Increase the DC (Variac 1) to obtain 250V on DC meter. Check that the instrument reads +19999 and overload neon strikes (do not overload for more than 5 seconds).
Reduce the DC signal to zero.
Check that the instrument recovers from overload.

(b) Switch to "-ve O/L" on test gear and repeat(a)

12.6 High Voltage On Auto Range.
Alternatively, use COHU 351 as a DC source.

Switch to AUTO range and check that the instrument reads on 10mV range.
Switch to manual sample.
Increase the DC signal to obtain 500V on DC meter. Take sample and check that the displayed reading is 500V.
Reduce the DC signal to zero and take a sample.
Check that the instrument reads on 100mV range.

## 13. TEMPERATURE CHECKS

**Switch ON and allow the instrument to stabilise for 90 minutes in ambient temperature (25°C approx.).**
**Set the μV OFFSET pot. as in 6.4, and the references (+ and -) as in 5.3.**

**Check that the input current reading is less than 20μV as in 4.4**

Place the instrument in an oven at 50°C and allow it to stabilise for more than 2 hours.

Check that the input current reading is less than 100 digits.

Check that the zero input reading is not more than 5 digits ±1 (i.e. ± 0.2μV/°C x 25).

Reset the μV OFFSET pot.

Check the basic functioning of the instrument.

Apply a 18.000V input on the 10V range.

Check that the new reading is 18.000V ± 6 digits.

Check the reading on opposite polarity.

Check the reading on all basic ranges.

Check that the zero output reading on AC is not more than 6 digits

Check that the zero output reading on Ω for all except the 10MΩ range is not more than 2 digits.

Check that the zero input reading on Ω for the 10MΩ range is not more than 6 digits.

Remove the instrument from the oven, and allow to cool for at least 2 hours.

Check the + and - reference on the 10V range as per 5.3.

Check zero input reading as in 5.6.

Check the basic functioning.

## B. DC FINAL CALIBRATION

Note: The instrument should have been operated for at least 48 hours at ambient temperature before final calibration at 20°C.

The instrument should be switched ON at least 1 hour before calibration.

Short circuit the input leads.

Check that the DVM reads zero on all ranges.

**DC STANDARDS**
**TEST EQUIPMENT**

| | |
|---|---|
| **DC potentiometer, 0.001%** | e.g. Cambridge Type 44248 |
| **Temperature Controlled Standard Cell Bank** | e.g. Guildline 9152T/4 |
| **Volts Ratio Box, 0.001%** | e.g. Sullivan T2100 |
| **DC Voltage Standard, 0.003%** | e.g. COHU 351 |

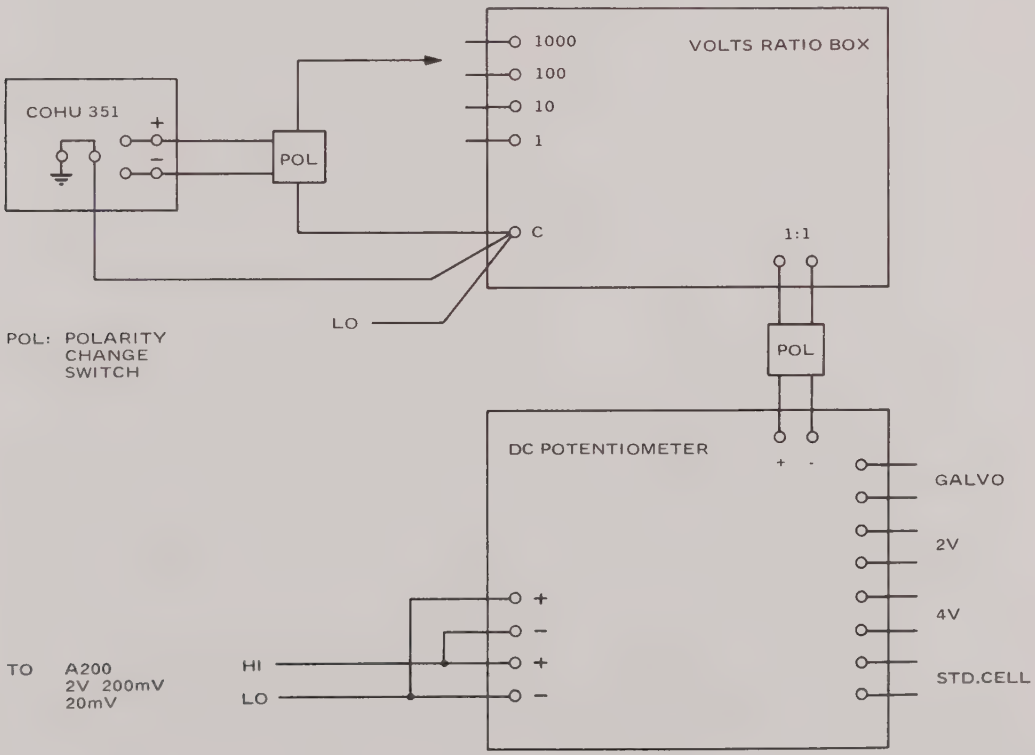



Fig. 8.4

The test equipment interconnection is shown in Fig. 8.4.

The equipment must be thoroughly stabilised at 20°C ± 1°C and must be operated, maintained and records kept in accordance with Standards Room Procedures.

The Volts Ratio Box and Standard Cell Bank should have valid certificates of calibration and values traceable to a National Calibration Authority.

The instrument should have been switched on for at least two hours in a 20°C (± 1°C) ambient, stable to 0.5°C.

1.1 A200/A203 only.

Switch to the 10mV range, DC FAST filter and 10/SEC.

Check that the noise scatter is less than 2μV (4 digits).

Switch to SLOW filter.

Check that the noise scatter is less than 1μV (3 digits).

1.2 Switch to the 10mV range (100mV on A220/A223) and SLOW filter.

A200, A203: Check that the μV OFFSET pot. covers more than 10 bits either side of zero.
A220, A223: Check that the μV OFFSET pot. covers more than 50 bits either side of zero.

Reset the μV OFFSET pot.

Check the zero reading on all ranges with FAST and SLOW filter.

1.3 Switch to 10V range and FAST filter.

Apply an input of +18.0005V and adjust RV5 (+ ref.) on pcb 3 to obtain +18.000/1 (See Drg. 5).

Reverse the polarity of the input and adjust RV4 (-ref.) on pcb 3 to obtain - 18.000/1 (see Drg. 5).

1.4 Check the linearity on the 10V range in 10% steps, using the RV622A (10kΩ) Dekavider and the COHU 351. Tolerance: ±1 digit.

1.5 Apply the inputs detailed and check each range as follows:

| Range | Filter | Input | Adjust | | pcb | Drawing | Reading | Limits |
|---|---|---|---|---|---|---|---|---|
| *10mV | SLOW | +18.000mV | (10mV) | RV3 | 26 | 5 | +18.000 | 2 |
| *10mV | SLOW | - 18.000mV | (10mV) | | | | - 18.000 | 2 |
| *10mV | FAST | +18.000mV | | | | | +18.000 | 4 |
| *10mV | FAST | - 18.000mV | | | | | - 18.000 | 4 |
| 100mV | FAST | +180.00mV | (100mV) | RV2 | 26 | 5 | +180.00 | 1 |
| 100mV | FAST | - 180.00mV | | | | | - 180.00 | 1 |
| 1V | FAST | +1.8000V | (1V) | RV1 | 26 | 5 | +1.8000 | 1 |
| 1V | FAST | - 1.8000V | | | | | - 1.8000 | 1 |
| 100V | FAST | +180.00V | (ATTN.) | RV1 | 6 | 1 & 2 | +180.00 | 1 |
| 100V | FAST | - 180.00V | | | | | - 180.00 | 1 |
| 1000V | FAST | +1100.0V | | | | 1 & 2 | +1100.0 | 1 |
| 1000V | FAST | - 1100.0V | | | | | - 1100.0 | 1 |

*A200/A203 only

1.6 Check the linearity on the lowest range in 10% steps, using the Cambridge 44248, or the Dekavider RV622A and COHU 351. Tolerance: ±1 digit.

## C. AC AND Ω FINAL CALIBRATION (A203 AND A223 ONLY)

The instrument should be switched on at least 1 hour before calibration.

Switch to DC and check the instrument reads zero on all ranges. If necessary adjust the μV OFFSET pot. on the lowest range with slow filter.

### 1. Ω MODE

1.1 Switch to OHM mode, 10/SEC, FAST filter and the 1kΩ range.

Short circuit the input leads.

Adjust RV1 pcb 16 to obtain a zero reading. If zero cannot be obtained cut link 2 on pcb 16, and repeat, (see Drg. 4).

Check that the instrument reads zero on all ranges. (10mV DC range is the same as 1kΩ).

If necessary, adjust C5 on pcb 5 on the 1MΩ and 10MΩ ranges to obtain zero (see Drg. 17).

1.2 Switch to the 100kΩ range.

Connect a known resistor of value 180k to the input.

Adjust RV4 on pcb 26 to obtain a reading 180.00kΩ, (see Drg. 5).

Switch to 1MΩ range.

Connect a 1.8MΩ known tolerance resistor and check that the reading is 1.8000 ± 10 digits.

1.3 Switch to the 10kΩ range.

Apply a known resistor of value 18kΩ to the input.

Adjust RV3 pcb 15 to obtain a reading of 18.000kΩ, (see Drg. 4).

Using the RS624A check the linearity in 10% steps. Tolerance: ±1 digit.

Switch to the 1kΩ range.

Connect a 1.8kΩ known tolerance resistor and check that the reading is 1.8000 ± 10 digits.

1.4 Switch to the 10MΩ range.

Check the linearity by applying suitable inputs. Tolerance: 0.5% of reading of ±6 digits.

1.5 A203 only.

By applying suitable inputs check AUTO ranging.

### 2. AC MODE

2.1 Switch to AC mode and 100mV range.

Short circuit the input leads.

Adjust RV3 pcb 14 to obtain minimum reading, (see Drg.3 "Set AC LIN").

Check that the instrument reads zero ± 6 digits on all ranges.

2.2 Switch to the 1V range.

Apply an input of 1.8V rms at 1kHz.

Adjust RV2 pcb 14 to obtain a reading of 1.8000V.

Check the reading at 100Hz, 10kHz, 20kHz. C7 selected in test (68pf ,82pf or 100pf)
Tolerance: ± 10 digits.

Check the reading at 50kHz, 100kHz. Tolerance: ± 180 digits.

Check the reading at 20Hz with SLOW filter. Tolerance ± 180 digits.

Apply 0.1V rms at 1kHz and reset RV3 pcb 14 to obtain 0.1000V, (see Drg.3, "Set AC LIN")

Check the linearity at 1kHz in 10% steps (using HP745A). Tolerance: ± 6 digits.

2.3 Switch to the 100mV range.

Apply an input of 180mV rms at 1kHz.

Adjust RV1 pcb 14 to obtain a reading of 180.00mV, (see Drg. 3).

Check the frequency response. Tolerance: 40Hz to 20kHz, ± 10 digits
20Hz to 100kHz, ± 180 digits.

Use SLOW filter below 100Hz.

Check the linearity at 1kHz. Tolerance: ±6 digits.

2.4 Switch to the 10V range.

Apply an input of 18V rms at 1kHz.

Adjust RV1 pcb 15 to obtain 18.000V, (see Drg. 3)

Switch to 100V range.

Apply an input of 180V rms at 1kHz.

Check that the reading is 180.00 ± 18 digits.

2.5 Switch to the 1000V range.

Apply an input of 800V rms at 400Hz.

Adjust RV2 pcb 15 to obtain a reading of 800.0V (see Drg. 3).

2.6 Switch to the 10V range.

Apply an input of 18V rms at 20kHz.

Adjust C6 pcb 15 to obtain a reading of 18,000 ± 18 digits (see Drg. 3).

Check the frequency response of the 10V and 100V ranges as per 2.3.

2.7 Switch to the 1000V range.

Apply an input of 800V rms at 20kHz.

Adjust C7 pcb 15 to obtain a reading of 800 ± 10 digits (see Drg. 3).

Check the frequency response, (limits as in 2.3. Take special care at high frequencies).

Tolerance: 40Hz to 20kHz, ± 10 digits
20Hz to 100kHz, ± 80 digits.

2.8 Switch to the 1V range and SLOW filter.

Apply an input of 1V rms at 1kHz via a 10kΩ resistor. and then direct.

Check that the change in reading is not more than 13 digits.

2.9 *Filter Settling Time, AC*

Switch off. Connect TG 1022/19 (See Appendix) to the FAN OUT socket (A200 9127 on pcb 13).

Switch DVM to AC, 1V range, FAST filter.

Apply an AC input to test gear, with the TEST switch UP (1.8V).

Switch to TEST. Check the reading when staticised.

Switch to NORMAL and 10/SEC. on DVM.

Check that the difference in reading does not exceed 18 digits for an input of 1.8000V rms.

Short circuit the input to the test gear.

Switch the DVM to MANUAL, SLOW filter.

Switch the test gear to RESPONSE, 3 sec. and TEST switch UP.

Apply an input of 1.8000V to the input of test gear.

Switch to test. Note the reading when staticised after 3 secs.

Switch to NORMAL and 10/SEC. on DVM.

Check that the difference does not exceed 18 digits.

## D. Testing The A204 FAN OUT Unit.

**FAN OUT TEST EQUIPMENT**

**A203 Digital Voltmeter, (Solartron)**

**Voltage divider** e.g. Sullivan 512 or ESI RV622A

**Oscilloscope**, from dc to 10MHz e.g. Solartron A100

**Power Supply Unit**, 1% Grade 0-10V dc in 0.1V steps, e.g. Solartron AS 1410.2

**Pulse Generator**, up to 200kHz, 20ns rise time 10$\mu$s pulse width and up to 10V amplitude e.g. Solartron GO 1101.2

In the following checks, Input and Output levels are checked on applied, as follows:

| | **Inputs** | **Outputs** |
|---|---|---|
| High or '1' | +2.4V to +6V<br>at 100$\mu$A or open circuit. | +2.4V to +6V<br>from a 6K$\Omega$ source. |
| Low or '0' | - 0.5V to +0.5V<br>at 5mA sink current. | -0.5V to +6V<br>at 10mA sink current. |

Plug the Fan Out Unit into the dvm edge connector socket A2009127 on pcb 13 (Earthy Mother Board).

Remove the blanking plate on the rear panel and secure the Fan Out socket SKA to the dvm rear panel using the blanking plate screws.

### Output Checks

**1. RANGE**

Select DC, LOCAL, 10/SEC, FAST filter.

Select each range in turn.

With the oscilloscope on dc,2V/cm and signal low connected to pin **HH** of the Fan Out Socket, check the output at pins **j**,**h** and **f** conform to the following tables.

1.1 **Code 1** (Pins A and C linked on pcb A2049027)

| **Volts Range** | **j** | **h** | **f** | **Ohms Range** |
|---|---|---|---|---|
| 1000V | 0 | 0 | 0 | 10M$\Omega$ |
| 100V | 0 | 0 | 1 | 1M$\Omega$ |
| 10V | 0 | 1 | 0 | 100k$\Omega$ |
| 1V | 0 | 1 | 1 | 10k$\Omega$ |
| 100mV | 1 | 0 | 0 | 1k$\Omega$ |
| 10mV<br>(DC only) | 1 | 0 | 1 | |

1.2 **Code 2** (B to A linked and normally supplied)

| Volts Range | j | h | f |
|---|---|---|---|
| 1000V | 0 | 0 | 1 |
| 100V | 0 | 1 | 0 |
| 10V | 0 | 1 | 1 |
| 1V | 1 | 0 | 0 |
| 100mV | 1 | 0 | 1 |
| 10mV | 1 | 1 | 0 |

1.3 **Code 2**

| Ohms Range | j | h | f |
|---|---|---|---|
| 10MΩ | 0 | 0 | 0 |
| 1MΩ | 0 | 0 | 1 |
| 100KΩ | 0 | 1 | 0 |
| 10KΩ | 0 | 1 | 1 |
| 1KΩ | 1 | 0 | 0 |

## 2. MODE

Using the oscilloscope as in 1., select DC AC and Ω in turn, checking pins **CC** and **DD** as follows.

2.1

| Mode | CC | DD |
|---|---|---|
| DC | 1 | 1 |
| AC | 0 | 1 |
| Ω | 1 | 0 |

## 3. STATICISED DISPLAY

Select DC.

Using the P.S.U. applied to the dvm signal input, check the output, using the oscilloscope set to dc and 1V/cm, at the pins detailed in 3.1 to 3.5.

3.1 **Range**

| Range | Applied Volts | Pins | | | |
|---|---|---|---|---|---|
| | | A | B | C | D |
| 1000V | 0 | 0 | 0 | 0 | 0 |
| | 0.1 | 1 | 0 | 0 | 0 |
| | 0.2 | 0 | 1 | 0 | 0 |
| | 0.3 | 1 | 1 | 0 | 0 |
| | 0.4 | 0 | 0 | 1 | 0 |
| | 0.5 | 1 | 0 | 1 | 0 |
| | 0.6 | 0 | 1 | 1 | 0 |
| | 0.7 | 1 | 1 | 1 | 0 |
| | 0.8 | 0 | 0 | 0 | 1 |
| | 0.9 | 1 | 0 | 0 | 1 |

3.2 **Range** 1000V

| Applied Volts | Pins | | | |
|---|---|---|---|---|
| | E | F | H | J |
| .0 | 0 | 0 | 0 | 0 |
| 1V | 1 | 0 | 0 | 0 |
| to | as per 3.1 | | | |
| 9V | 1 | 0 | 0 | 1 |

3.3 **Range** 100V

| Applied Volts | Pins | | | |
|---|---|---|---|---|
| | K | L | M | N |
| 0 | 0 | 0 | 0 | 0 |
| 1V | 1 | 0 | 0 | 0 |
| to | as per 3.1 | | | |
| 9V | 1 | 0 | 0 | 1 |

3.4 **Range** 10V

| Applied Volts | Pins | | | |
|---|---|---|---|---|
| | P | R | S | T |
| 0 | 0 | 0 | 0 | 0 |
| 1V | 1 | 0 | 0 | 0 |
| to | as per 3.1 | | | |
| 9V | 1 | 0 | 0 | 1 |

3.5 **Range** 1V

| Applied Volts | Pin |
|---|---|
| | U |
| 0 | 0 |
| 1V | 1 |

## 4. POLARITY

Using the P.S.U. and oscilloscope as in 3., apply an input on each polarity and check the outputs at Pins **d** and **e**.

4.1 **Polarity**

| | Pins | |
|---|---|---|
| | d | e |
| Positive (+) | 1 | 0 |
| Negative (-) | 0 | 1 |

## 5. OVERLOAD

Using the P.S.U. and oscilloscope as in 3, select 1V range.

5.1 Set the P.S.U. to 1.9V and adjust the mv pot. so that overload can be applied and removed,

5.2 Check pin **c** is at '1' on overload and at '0' when overload is removed.

## 6. PRINT COMMAND and DATA CAN CHANGE

Using the P.S.U. and oscilloscope as in 3 check the following outputs.

6.1 'Level'

| Rate | Pin x | Pin v | |
|---|---|---|---|
| 10/SEC | 1 | 0 | |
| MANUAL | **0 pulse** | **1 pulse** | for approx. 19ms during DRIFT CORRECT |

See FAN OUT SHEETS 1 & 2 with waveforms.

6.2 **'Pulse'** Select MANUAL

**Pin u**

1 pulse of approximately 10$\mu$s
8$\mu$s after End of Ramp Down.

## 7. GATED CLOCK

Set the oscilloscope to 1V/cm and 2$\mu$s/cm

7.1 Check that the clock pulses at pin **k** correspond to the data displayed.

7.2 E.G. obtain a dvm display of 5 digits using the PSU and Voltage divider.

Note that 5 clock pulses are present.

7.3 Increase the dvm display to 6 digits.

Note that 6 clock pulses are present.

See FAN OUT Sheets 1 & 2 with waveforms.

# Input Checks
# (Remote Commands)

## 8. CONTROL

8.1 Select REMOTE on the dvm.
Check that the REMOTE Signal is illuminated.

8.2 Check that the dvm will not operate on any of the front panel controls except MANUAL sample, 10/SEC and POWER.

8.3 Command REMOTE externally (using TG 1022/17 or by connecting pin **r** to **HH**).

Check that this operation disables all front panel controls except POWER, and note the dvm is in the 1000V range.

## 9. CONTROL (CONTACT) SAMPLE

Using the P.S.U set to 1.8V carry out the following checks.

9.1 Set the dvm display to zero (if necessary, short circuit the input leads, cancel REMOTE externally and select 10/SEC for a zero reading. Command REMOTE externally as in 8.3).

9.2 Apply 1.8V to the dvm input.

Check that the dvm samples (displays a reading) when contact sample is operated (using the TG 1022/17 or by connecting pin s to pin **HH**).

## 10. PULSE SAMPLE

Switch on the Pulse Generator and set one shot, 3.2V amplitude and 12$\mu$s pulse width.

10.1 Set the dvm display to zero by repeating 9.1.

10.2 Apply 1.8V to the dvm input.

Apply the pulse generator +ve output to pin **t** via the generator coaxial lead.

Press the one shot button on the generator, and check that the dvm samples (alternatively command pulse sample on the TG 1022/17).

## 11. RANGE

Cancel REMOTE externally (using TG 1002/17 or by disconnecting pin **r** from pin **HH**).

Select 10/SEC on the dvm front panel, ensuring that REMOTE remains selected on the front panel.

11.1 Command the following ranges (using TG 1022/17 or by connecting pins **p, n** and **m** to pin **HH** where '0' is indicated ), checking that each range is correctly displayed.

| Voltage Range | p | n | m |
|---|---|---|---|
| 1000V | 0 | 0 | 0 |
| 100V | 0 | 0 | 1 |
| 10V | 0 | 1 | 0 |
| 1V | 0 | 1 | 1 |
| 100mV | 1 | 0 | 0 |
| 10mV | 1 | 0 | 1 |

## 12. MODE

12.1 Command the following modes ( using TG 1022/17 or by connecting pins **AA** and **BB** to pin **HH** where '0' is indicated as follows, checking that each mode is correctly displayed.

| Mode | AA | BB |
|---|---|---|
| DC | 1 | 1 |
| AC | 0 | 1 |
| Ω | 1 | 0 |

## 13. AUTO RANGE

Command Auto Range ( using TG 1022/17 or by connecting pin **y** to pin **HH**).

13.1 Set 1V on the P.S.U. and apply this to the dvm input via the Voltage Divider.

13.2 Set the Voltage divider for an output of 18mV (0, 0, 1, 8) and check the dvm reads 18mV on the 10mV range.

13.3 Increase the input for a dvm reading of more than 19.000mV.
Check that the dvm changes to the 100mV range.
Reduce the input to less than 018.00mV.
Check the dvm changes to the 10mV range.
Disconnect pin **y** from pin **HH**.

## 14. RESPONSE

14.1 Command 1V range as in 11.1.

14.2 Command **SLOW** response (using TG 1022/17 or by connecting pin **z** to pin **HH**).

14.3 Short circuit the dvm input leads for a zero reading; select MANUAL on dvm front panel.

14.4 Apply approximately 1.8V to the dvm. Press the MANUAL button.

14.5 Note the dvm displays WAIT for approximately 1 second. The display then reads the applied voltage.

14.6 Cancel SLOW (on disconnect pin **z** from pin **HH**).

## 15. DATA HAS CHANGED

15.1 Set the oscilloscope to 2V/cm and 2ms/cm and connect signal Hi to pcb 28 pin 15.

15.2 Set the pulse generator as in 10. PULSE SAMPLE, connecting +ve output to pin **t**.

15.3 Triggering the oscilloscope from the Pulse Generator, apply PULSE SAMPLE (press one shot on the pulse generator).

Check that pcb 28 pin 15 goes Low after approximately 10ms.

15.4 Connect pin **w** to pin **HH** (i.e. setting Logic '0')
Apply PULSE SAMPLE as in 15.3 and check that pcb 28 pin 15 goes Low after approximately 1ms.

# E. APPENDIX

## Ancillary Test Equipment

### 1. FET NOISE SELECTION

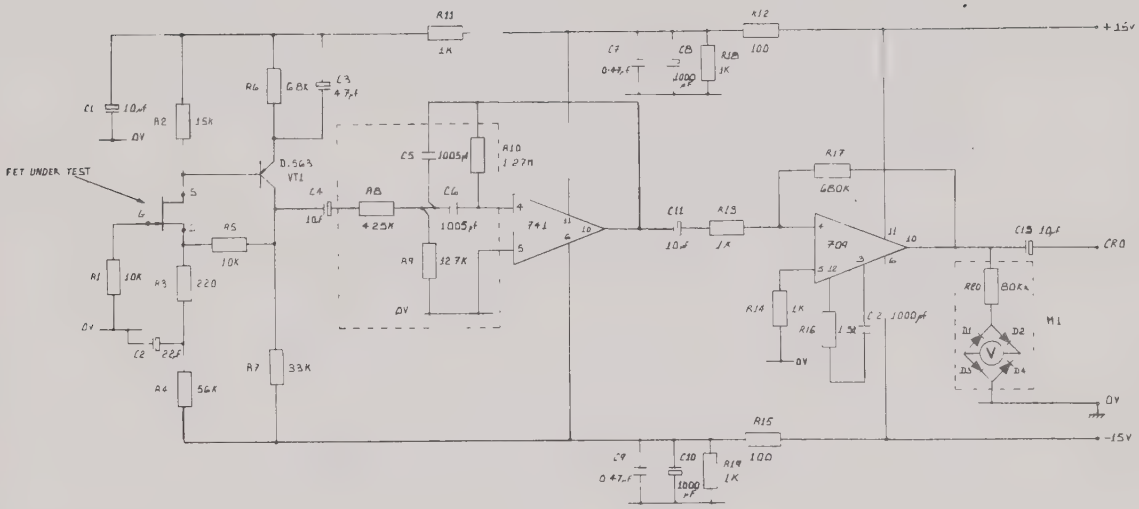



**Fig. 8.5** T.G. 1030. TR1 and TR3 (A200, A203 Input amp.) pcb 2, Low Noise Selection.

**Use** Initial selection and replacement of TR1 and TR3 on pcb 2 (Input amp., A200 and A203 only).

See **Section 7, INPUT AMPLIFIER 6.**

**Description**

1) The power rails must be from a dc source set to + 15V and - 15V (± 0.5V) at 10ma load.

2) The circuit comprises a high gain narrow band amplifier.

   The FET under test is biased to a point of prominent noise.

   Noise is amplified by VT1 and fed to operational amp. IC SN72741 which has a frequency response of 2.45 kHz (± 300 Hz to -3db).

   A second IC operational amp., SN72709, increases the circuit gain to 5 x $10^6$

3) The meter, M1 (SIFAM, Solartron spec. no. 34003060) has a FSD of 5V r.m.s. and therefore indicates 1$\mu$V of FET noise at full scale.

   From the C.R.O. socket, the noise may be seen on a display. This is less precise to read than the meter.

Noise Selection Test

1) Switch the power supplies ON.

2) Check the meter settles to within 0 + 0.05μV (FSD = 1μV).

3) Plug in the FET under test to the test socket.

4) Note the meter reading.

For a 2N 4303, < 0.3μV is an acceptable noise level.

**TG 1030 Servicing Note**

**C5 and C6**

If either one of these is changed both must be reselected to a matching tolerance of 0.5%.

## 2. REMOTE COMMANDS

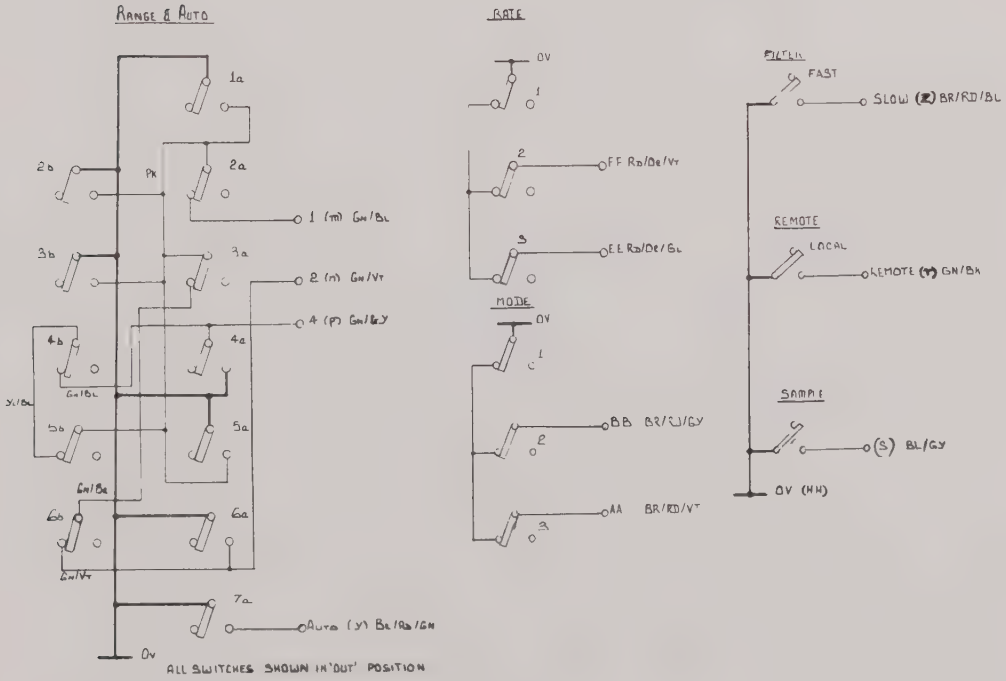



Fig. 8.6 TG 1022/17. Remote Commands

**Use** See Section 8. A paras. 11.6 to 11.8 and 8. D para.8.

## TRUTH TABLES

| Range | Switch | 4 | 2 | 1 | Auto |
|---|---|---|---|---|---|
| 10MΩ 1000V | 1 | 0 | 0 | 0 | 1 |
| 1MΩ 100V | 2 | 0 | 0 | 1 | 1 |
| 100kΩ 10V | 3 | 0 | 1 | 0 | 1 |
| 10kΩ 1V | 4 | 0 | 1 | 1 | 1 |
| 1kΩ 100mV | 5 | 1 | 0 | 0 | 1 |
| - 10mV | 6 | 1 | 0 | 1 | 1 |
| Auto Auto | 7 | | | | 0 |

| Mode | Switch | AA | BB |
|---|---|---|---|
| DC | 1 | 1 | 1 |
| AC | 2 | 0 | 1 |
| Ω | 3 | 1 | 0 |

### 3. FILTER SETTLING TIME

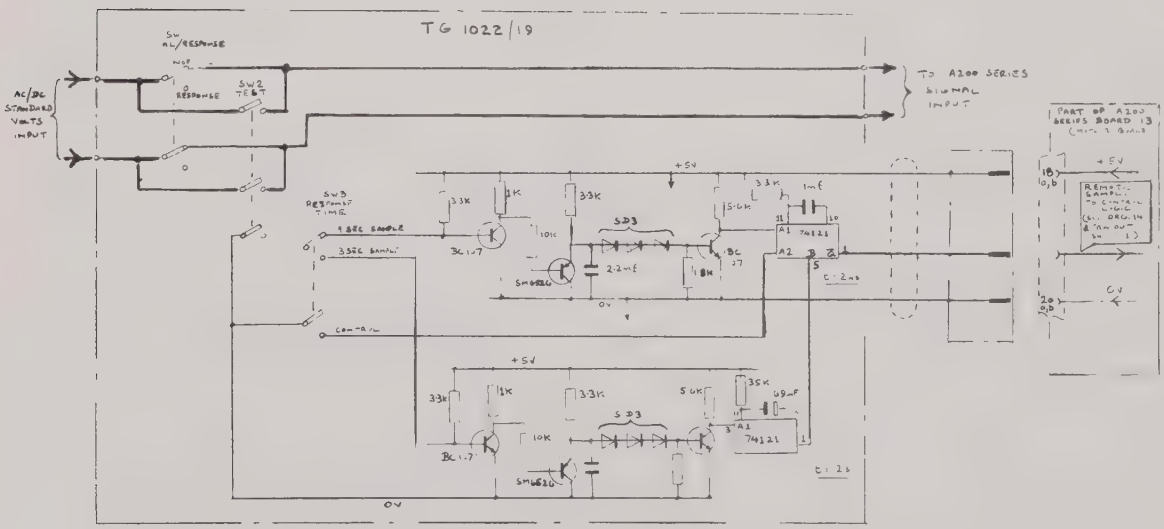



Fig. 8.7 TG 1022/19. Filter Settling Time

**Use** See Section 8.A para. 11.9 and 8.C para. 2.9

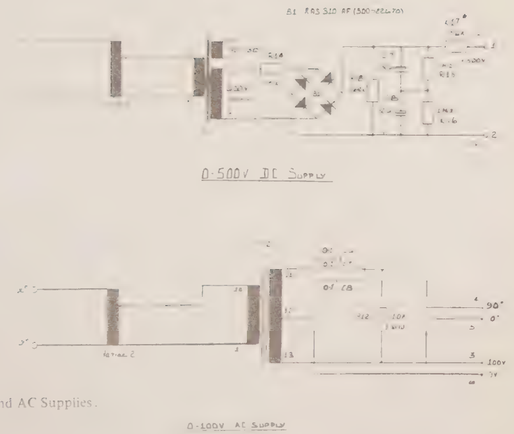



Fig. 8.8 (ii) TG 1022/18/02 DC and AC Supplies.

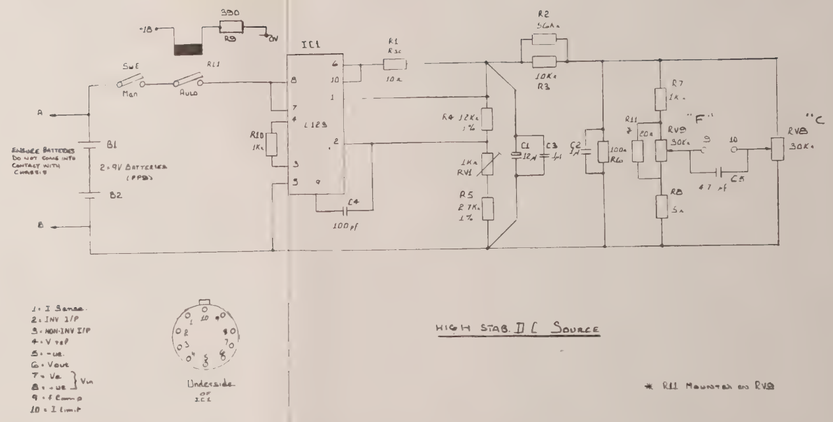



Fig. 8.8 (iii) TG 1022/18/03 High Stab. DC Source .

## 4. SERIES AND COMMON MODE REJECTION

Use See Section 8.A para 12

Notes

Fig. 8.8.(i) shows the Basic Unit

Fig. 8.8.(ii) shows:-

MAINS DISTRIBUTION { L.T. P.S.U. + 18V dc for IC1, Fig. 8.8.(iii)
H.T. P.S.U. 0 to + 500V dc
A.C. P.S.U. 0 to 100V ac

Fig. 8.8.(iii) High Stab. DC Source.

G.P is at 10 (high) and 9 (low)
"A" and "B" are battery test points to DC Multimeter.

Fig. 8.8 (iv) DC Multimeter and AC Millivoltmeter

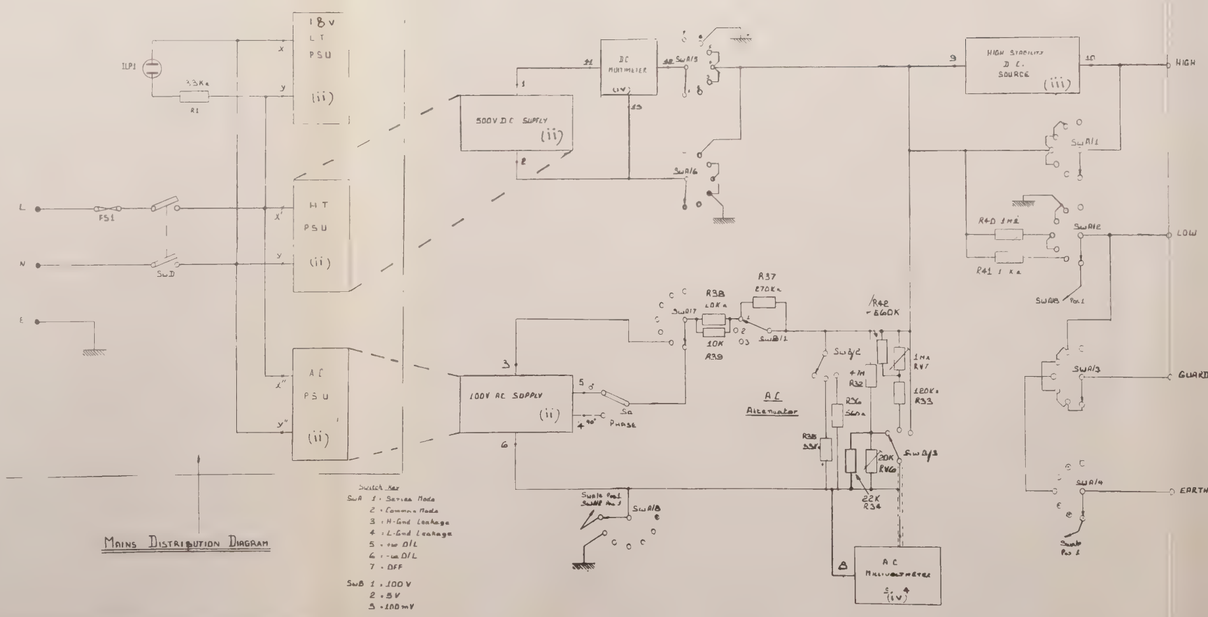



Fig. 8.8 (i) TG 1022/18/01 Series and Common Mode Test Box.

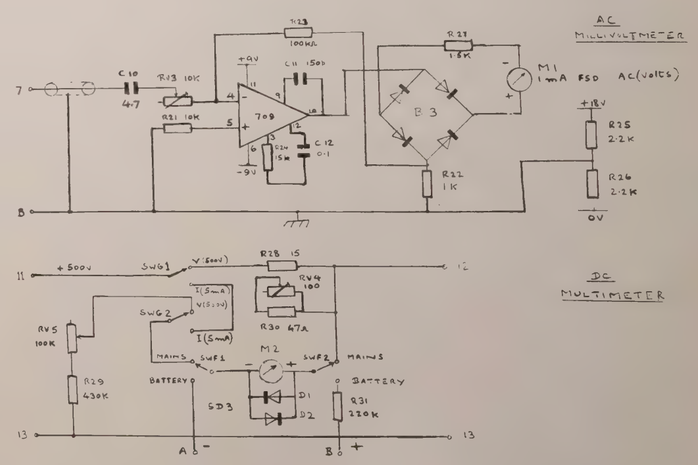



Fig. 8.8 (iv) TG 1022/18/04 DC Multimeter and AC Millivoltmeter.

## F. DVM TYPES A205 AND A225

1. Carry out the initial calibration and set up the DC and OHMS ranges as with DVM Types A203 for A205 or A223 for A225.

2. Ensure that the instrument has been switched on for at least 1 hour.

3. Switch to AC mode, Fast Response, 10 rdgs. per second, and 100mV range.

   With a short-circuited input lead, adjust RV2 on PCB 16 to obtain a reading of zero. Check that the instrument reads less than 2 bits on all other AC ranges.

4.a) Select the 1V range and, using a Hewlett-Packard 745a or similar instrument, apply an input of 20.00mV rms at 400Hz.

Adjust RV5 on PCB 41 (AC LINEARITY) to obtain a reading of 0.0200 Volts. Increase the input to 1.9000 Volts at 400Hz and adjust RV2 on PCB 41 (AC 1V) to obtain a reading of 1.9000 Volts.

b) Apply the inputs as shown in the table below, checking that the readings are within the specified limits.

**TABLE 1**

| Voltage | Frequency | Allowable Error (bits) |
|---|---|---|
| 1.9000V | 10Hz | 200 - Select slow filter for this reading. |
| 1.9000V | 40Hz | 35 |
| 1.9000V | 10kHz | 35 |
| 1.9000V | 60kHz | 200 |
| 1.9000V | 100kHz | 200 |
| 1.0000V | 400Hz | 10 |
| 1.0000V | 10kHz | 25 |
| 1.0000V | 100kHz | 190 |
| 0.3000V | 400Hz | 10 |
| 0.3000V | 10kHz | 18 |
| 0.3000V | 100kHz | 180 |

| | | |
|---|---|---|
| 0.1000V | 400Hz | 10 |
| 0.1000V | 10kHz | 15 |
| 0.1000V | 100kHz | 180 |
| 0.0100V | 400Hz | 10 |
| 0.0100V | 10kHz | 15 |

5.a) Select the 100mV range and apply an input of 190.00mV at 400Hz. Adjust RV1 on PCB 41 (AC 100mV) to obtain a reading of 190.00mV ± 0.02mV.

b) Apply inputs of 190.00mV at the frequencies shown in table 2 and check the readings are within the specified limits.

TABLE 2

| Frequency | Allowable error (bits) |
|---|---|
| 10Hz | 200 |
| 40Hz | 35 |
| 10kHz | 35 |
| 60kHz | 200 |
| 100kHz | 200 |

6.a) Select 10V range and apply 19.000V at 400Hz adjust RV1 on PCB 15 (AC 10V/100V) to obtain a reading of 19.000V.

b) Apply 19.000V at 10kHz and adjust C6 on PCB 15 (AC 10V/100V HF) to give a reading of 19.000V ± 10 bits, and note this reading.

Select the 100V range and apply 190.00V at 10kHz. Re-adjust C6 on PCB 15 (AC 10V/100V HF) to share errors between 10V and 100V ranges at 10kHz.

Check the frequency response of both 10V and 100V ranges to within the limits shown in table 2 and provide minor re-adjustments of C6 if necessary.

7.a) Select 1000V range and apply 800.0V at 400Hz using a twisted pair type of input lead. Adjust RV2 on PCB 15 to give a reading of 800.0 Volts.

b) Increase the frequency to 20kHz and adjust C7 on PCB 15 to give a reading of 800.0 Volts.

Check the frequency response to within the limits shown in Table 2.

# SECTION 9 Component Parts List

## COMPONENT PARTS LIST

## ABBREVIATIONS

### Circuit References

| | |
|---|---|
| B | Battery |
| C | Capacitor (μF) |
| CSR | Thyristor |
| D | Diode |
| FS | Fuse |
| IC | Integrated Circuit |
| L | Inductor |
| LP | Lamp (including Neon) |
| LK | Link |
| M | Meter |
| MSP | Mains Selector Panel |
| PL | Plug |
| R | Resistor (Ω) |
| RL | Relay |
| S | Switch |
| SK | Socket |
| T | Transformer |
| TP | Terminal Post (or Test Point) |
| TR | Transistor |
| V | Valve |
| X | Other Components |

Also Used:-

| | |
|---|---|
| RNL | Non Linear Resistor (Ω) |
| RV | Variable Resistor (Ω) |

### Component Composition

### FIXED RESISTORS

| | |
|---|---|
| Carbon Composition | CACP |
| Carbon Film | CAFM |
| Cracked Carbon | CKCA |
| Metal Film | MEFM |
| Metal Oxide | MEOX |
| Power Wirewound | POWW |
| Precision Wirewound | PRWW |
| Temperature Sensitive | TEMP |
| Thick Film | TKFM |
| Thin Film | TNFM |
| Voltage Sensitive | VOLT |

### Component Composition (Cont'd)

### VARIABLE RESISTORS

| | |
|---|---|
| Wirewound Preset Single Turn | WWPS |
| Wirewound Preset Multiturn | WWPM |
| Wirewound Front Panel Single Turn | WWFS |
| Wirewound Front Panel Multiturn | WWFM |
| Carbon Preset Single Turn | CAPS |
| Carbon Preset Multiturn | CAPM |
| Carbon Front Panel Single Turn | CAFS |
| Carbon Front Panel Multiturn | CAFM |
| Cermet Preset Single Turn | CMPS |
| Cermet Preset Multiturn | CMPM |
| Cermet Front Panel Single Turn | CMFS |
| Cermet Front Panel Multiturn | CMFM |

### CAPACITORS

| | |
|---|---|
| Air | AIR |
| Aluminium Electrolytic | ALME |
| Aluminium Solid | ALMS |
| Polycarbonate | CARB |
| Ceramic | CERM |
| Polyester Foil | ESTF |
| Polyester Metallised | ESTM |
| Glass | GLAS |
| Mica | MICA |
| Metallised Lacquer | MLAC |
| Paper Foil | PAPF |
| Paper Metallised | PAPM |
| PTFE | PTFE |
| Polypropylene Film | PYLN |
| Polystyrene | STYR |
| Tantalum Dry | TAND |
| Tantalum Foil | TANF |
| Tantalum Wet | TANW |

## Component Parts List
## for
## Accessories
## (MD A209)

| General Description | Solartron Part No. |
|---|---|
| Input Lead Assy | ADA2000168 |
| Clip, Alligator (Red) | 355900670 |
| Clip, Alligator (Black) | 355900660 |
| Prod. Test Black | 351901010 |
| Prod. Test Red | 351901020 |
| Fuse 750mA Slo-Blo* | 360103070 |
| Fuse 300mA Slo-Blo* | 360103170 |
| Lock Plate (Mains Selector Plate) | FDA2000145 |
| Bag Self Sealing | 810000210 |
| Bag Self Sealing | 810000140 |
| Handle (Rack MTG) | 429700101 |

* As indicated on Mains Selector Plates

## Component Parts List
## for
## Main Frame
## (MD A209)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 | CACP | 1M | ¼W | 10% | 172361000 |
| R2 | CACP | 1M | ¼W | 10% | 172361000 |
| R10 | POWW | 180 | 6W | 5% | 174321800 |
| | Terminal Standoff (Ins.) | | | | 355400111 |
| | Resistor Bkt. Fab | | | | FDA2000113 |
| C1 | PAPM | 0.047 | 630V | 20% | 208300059 |
| C2 | PAPM | 0.047 | 630V | 20% | 208300059 |
| TR1 | Transistor 2N3055 | | | | 300552340 |
| | Mica Washer | | | | 300584050 |
| | Transistor Cover | | | | 300584620 |
| | Mains Lead | | | | 480140200 |
| | Board Guide | | | | A2000042 |
| | Board Clamp | | | | A2000048 |
| | L.H. Side Panel | | | | FDA2000034 |
| | R.H. Side Panel | | | | FDA2000032 |
| | Nixie Housing | | | | A2100020 |

| Cct Ref. | General Description | Solartron Part No. |
|---|---|---|
| T1 | Mains Transformer | 3096002-05 |
| | 9-way Tagstrip | A2000115 |
| SWJ | Switch Slider D.P.D.T. | 375000100 |
| SWK | Switch Slider D.P.D.T. | 375000100 |
| SWH | Mains D.P.S.T. Switch Push Button | 377000290 |
| | Extension Shaft | A2000139 |
| | Red Knob | 400001750 |
| | Black Knob | 400001720 |
| | Escutcheon | 420610050 |
| F1 | Fuse Holder | 360202000 |
| | Fuse Link 300mA Slo-Blo* | 360103170 |
| | Fuse Link 750mA Slo-Blo | 360103070 |
| | Cover Plate | A2000122 |
| | Lock Plate (Mains Selector Plate) | FDA2000133 |
| | * as indicated on Mains Selector Plates | |

## Component Parts List
## for
## Floating Box Assembly
## (MD A209)

| Cct Ref | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| RV1 | CAFS | 4.7k | ¼W | 20% | 136834700 |
| C1 | CERM | 0.047 | 25V | +10% -20% | 241944700 |
| T2 | Quad Toroid Block | | | | 309600605 |
| | 5-way Skt | | | | 352105010 |
| | Housing Fab | | | | FD16370002 |
| | Coil | | | | 301200101 |
| | End Cap | | | | 16370007 |
| | Core Rod | | | | 16370008 |
| | Spire Fastener | | | | 412006570 |
| | Extension Spindle | | | | A2000179 |
| | P.T.F.E. Stand Off | | | | 355400590 |

### Quad Toroid Block T2 Sub Assembly

| Cct Ref. | General Description | | | Solartron Part No. |
|---|---|---|---|---|
| R1 to R3 | CACP | 1k | 1/8W | 172031000 |
| R4 | CACP | 10k | 1/8W | 172041000 |
| R5 | CACP | 100Ω | 1/8W | 172021000 |
| C1 to C3 | CERM | 470p | 500V | 241324700 |

# Component Parts List
# for
# Printed Circuit Board A2009002
# (Input Amplifier, A200 and A203)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 | MEFM | 10k | 1/16W | 1% | 192641002 |
| R2 | CACP | 1M | 1/8W | 10% | 172061000 |
| R3 | MEFM | 10k | 1/16W | 1% | 192641002 |
| R4 | MEFM | 220 | 1/16W | 1% | 192622202 |
| R5 | CACP | 56k | 1/8W | 10% | 172045600 |
| R6 | MEFM | 2.2k | 1/16W | 1% | 192632202 |
| R7 | CACP | 22k | 1/8W | 10% | 172042200 |
| R8 | MEFM | 2.2k | 1/16W | 1% | 192632202 |
| R9 | CACP | 470k | 1/8W | 10% | 172054700 |
| R10 | MEFM | 2.2k | 1/16W | 1% | 192632202 |
| R11 | MEFM | 10k | 1/16W | 1% | 192641002 |
| R12 | CACP | 1k | 1/8W | 10% | 172031000 |
| R13 | CACP | 1M | 1/8W | 10% | 172061000 |
| R14 | CACP | 1k | 1/8W | 10% | 172031000 |
| R15 | MEFM | 15k | 1/16W | 1% | 192641502 |
| R16 | MEFM | 220 | 1/16W | 1% | 192622202 |
| R17 | CACP | 56k | 1/8W | 10% | 172045600 |
| R18 | MEFM | 10k | 1/16W | 1% | 192641002 |
| R19 | CACP | 33k | 1/8W | 10% | 172043300 |
| R20 | CACP | 6.8k | 1/8W | 10% | 172036800 |
| R21 | CACP | 10k | 1/8W | 10% | 172041000 |
| R22 | CACP | 220k | 1/8W | 10% | 172052200 |
| R23 | CACP | 33k | 1/8W | 10% | 172043300 |
| R24 | CACP | 150 | 1/8W | 10% | 172021500 |
| R25 | CACP | 1.8k | 1/8W | 10% | 172031800 |
| R26 | CACP | 22k | 1/8W | 10% | 172042200 |
| R27 | CACP | 22k | 1/8W | 10% | 172042200 |
| R28 | CACP | 3.3k | 1/8W | 10% | 172033300 |
| R29 | CACP | 27k | 1/8W | 10% | 172042700 |
| R30 | CACP | 1k | 1/8W | 10% | 172031000 |
| R31 | MEFM | 82 | 1/16W | 1% | 192618202 |
| R32 | CACP | 100k | 1/8W | 10% | 172051000 |
| R33 | MEFM | 470 | 1/16W | 1% | 192624702 |
| R34 | MEFM | 2.2k | 1/16W | 1% | 192632202 |
| R35 | MEFM | 10k | 1/16W | 1% | 192641002 |
| R36 | CACP | 6.8k | 1/8W | 10% | 172036800 |
| R37 to R42 | CACP | 1k | 1/8W | 10% | 172031000 |
| R43 | CACP | 470 | 1/8W | 10% | 172024700 |
| R44 | CACP | 470 | 1/8W | 10% | 172024700 |
| R45 | CACP | 100k | 1/8W | 10% | 172051000 |
| R46 | MEFM | 10 | 1/16W | 1% | 192611002 |
| R47 | CACP | 680k | 1/8W | 10% | 172056800 |
| R48 | CACP | 470 | 1/8W | 10% | 172024700 |
| R49 | CACP | 470k | 1/8W | 10% | 172054700 |
| R50 | CACP | 33k | 1/8W | 10% | 172043300 |
| R51 | CACP | 68 | 1/8W | 10% | 172016800 |
| R52 | CACP | 39 | 1/8W | 10% | 172013900 |
| R53 | CACP | 470 | 1/8W | 10% | 172024700 |
| R54 | CACP | 680k | 1/8W | 10% | 172056800 |
| R55 | CACP | 22k | 1/8W | 10% | 172042200 |
| R57 | CACP | 100 | 1/8W | 10% | 172021000 |
| RV1 | CMPM | 100 | | | 110016040 |
| RV2 | WWPS | 10k | | | 130541000 |
| C1 | ESTM | 0.047 | 100V | 10% | 225444700 |
| C2 | ESTM | 0.047 | 100V | 10% | 225444700 |
| C3 | MICA | 22p | 350V | 5% | 250312200 |
| C4 | TAND | 22 | 15V | 20% | 265672200 |
| C5 | MICA | 1000p | 350V | 5% | 250331000 |
| C6 | TAND | 15 | 20V | 20% | 265871500 |
| C7 | MICA | 1000p | 350V | 5% | 250331000 |
| C8 | MICA | 100p | 350V | 5% | 250321000 |

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| C9 | TAND | 47 | 20V | 20% | 265874700 |
| C10 | CERM | 1000p | 500V | 20% | 241331000 |
| C11 | MICA | 470p | 350V | 5% | 250324700 |
| C12 | ESTM | 0.01 | 100V | 10% | 225441000 |
| C13 | TAND | 22 | 15V | 20% | 265672200 |
| C14 | TAND | 15 | 20V | 20% | 265871500 |
| C15 | TAND | 15 | 20V | 20% | 265871500 |
| C16 | ESTM | 0.22 | 100V | 10% | 225452200 |
| C17 | TAND | 22 | 15V | 20% | 265672200 |
| C18 | CERM | 33p | 200V | 10% | 240713300 |
| C19 | CERM | 33p | 200V | 10% | 240713300 |
| C20 | ESTM | 0.22 | 100V | 10% | 225452200 |
| C21 to C23 | ESTM | 0.22 | 100V | 10% | 225452200 |
| C24 | ESTM | 0.047 | 100V | 10% | 225444700 |
| C25 | ESTM | 0.047 | 100V | 10% | 225444700 |
| C26 | ALME | 50 | 40V | +50% −10% | 273774700 |
| C27 | ALME | 50 | 40V | +50% −10% | 273774700 |
| C28 | CERM | 0.047 | 25V | +50% −20% | 241944700 |
| C29 | ESTM | 0.047 | 100V | 10% | 225444700 |
| C30 | ESTM | 0.047 | 100V | 10% | 225444700 |
| D1 | Zener | 4.7V | | | 300521470 |
| D2 | SD3 | | | | 300522160 |
| D3 | SD3 | | | | 300522160 |
| D4 | Zener | 6.2V | | | 300521240 |
| D5 | Zener | 3.3V | | | 300521860 |
| D6 | IN3595 | | | | 300523590 |
| D7 | IN3595 | | | | 300523590 |
| D8 | Zener | 25V | | | 300525090 |
| D9 | Zener | 25V | | | 300525090 |
| D10 | IN3595 | | | | 300523590 |
| D11 | IN3595 | | | | 300523590 |
| D12 | Zener | 4.7V | | | 300521470 |
| D13 | SD3 | | | | 300522160 |
| TR1 | 2N4303 | | | | 300553160 |
| TR2 | BFX37 | | | | 300553030 |
| TR3 | 2N4303 | | | | 300553160 |
| TR4 | BFX37 | | | | 300553030 |
| TR5 | BFX37 | | | | 300553030 |
| TR6 to TR8 | BC107S | | | | 300553320 |
| TR9 to TR13 | 2N2369 | | | | 300552390 |
| TR14 | 40673 | | | | 300555210 |
| TR15 | U 1897 E | | | | 300553800 |
| TR16 | U 1897 E | | | | 300553800 |
| IC1 | SC9495G | | | | 510090030 |
| IC2 | 741C | | | | 510000591 |
| Integrated Circuit Spreader Pads | | | | | 300584340 |
| Plate | | | | | A2000071 |
| Rear Plate | | | | | A2000073 |
| Insulating Rubber | | | | | A2000074 |
| Chopper Box Moulding Fabrication | | | | | DA2000080 |

## Component Parts List
## for
## Printed Circuit Board A2209002
## (Input Amplifier, A220 and A223)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 | CACP | 220k | 1/8W | 10% | 172052200 |
| R2 | CACP | 470 | 1/8W | 10% | 172024700 |
| R3 | CACP | 10k | 1/8W | 10% | 172041000 |
| R4 | CACP | 100k | 1/8W | 10% | 172051000 |
| R5 | CACP | 220k | 1/8W | 10% | 172052200 |
| R6 | CACP | 39 | 1/8W | 10% | 172013900 |
| R7 | CACP | 220k | 1/8W | 10% | 172052200 |
| R8 | CACP | 10k | 1/8W | 10% | 172041000 |
| R9 | CACP | 68k | 1/8W | 10% | 172046800 |
| R10 | CACP | 330 | 1/8W | 10% | 172023300 |
| R11 | CACP | 330 | 1/8W | 10% | 172023300 |
| R12 | CACP | 10k | 1/8W | 10% | 172041000 |
| R13 | CACP | 10k | 1/8W | 10% | 172041000 |
| R14 | CACP | 22k | 1/8W | 10% | 172042200 |
| R15 | CACP | 22k | 1/8W | 10% | 172042200 |
| R16 | CACP | 3.3k | 1/8W | 10% | 172033300 |
| R17 | CACP | 3.3k | 1/8W | 10% | 172033300 |
| R18 | CACP | 10k | 1/8W | 10% | 172041000 |
| R19 | CACP | 10k | 1/8W | 10% | 172041000 |
| R20 | CACP | 33k | 1/8W | 10% | 172043300 |
| R21 | CACP | 220k | 1/8W | 10% | 172052200 |
| R22 | CACP | 100k | 1/8W | 10% | 172051000 |
| R23 | MEFM | 10 | 1/16W | 1% | 192611002 |
| R25 | CACP | 220k | 1/8W | 10% | 172052200 |
| R26 | CACP | 470 | 1/8W | 10% | 172024700 |
| R27 | CACP | 100 | 1/8W | 10% | 172021000 |
| RV1 | WWPM | 20k | 1/2W | 10% | 121242000 |
| C1 | ESTM | 0.47 | 100V | 10% | 225454700 |
| C2 | ESTM | 0.047 | 100V | 10% | 225444700 |
| C3 | ESTM | 0.047 | 100V | 10% | 225444700 |
| C4 | ALME | 200 | 10V | 20% | 273182200 |
| C6 | ESTM | 0.47 | 100V | 10% | 225454700 |
| C7 | TAND | 47 | 20V | 20% | 265874700 |
| C8 | CERM | 0.047 | 25V | 20% | 241944700 |
| C10 | ESTM | 1 | 100V | 10% | 225461000 |
| C11 | ALME | 47 | 40V | +100% -20% | 273774700 |
| C12 | ALME | 47 | 40V | +100% -20% | 273774700 |
| C13 | CERM | 1000p | 500V | 20% | 241331000 |
| C14 | ESTM | 0.047 | 100V | 10% | 225444700 |
| C15 | ESTM | 0.047 | 100V | 10% | 225444700 |
| C16 | CERM | 3.3p | 700V | | 240203300 |
| C17 | STYR | 100p | 125V | 10% | 210221000 |
| D1 to D4 | 1N3595 | | | | 300523590 |
| D5 | SD3 | | | | 300522160 |
| D6 | SD3 | | | | 300522160 |
| D7 | Zener | 3.9V | | | 300521420 |
| D8 | Zener | 3.9V | | | 300521420 |
| D10 | Zener | 25V | | | 300525090 |
| D11 | Zener | 25V | | | 300525090 |
| D12 | Zener | 13V | | | 300523920 |
| D13 | Zener | 13V | | | 300523920 |
| TR1 | 40673 | | | | 300555210 |
| TR2 | 40673 | | | | 300555210 |
| TR3 | BC107/S | | | | 300553320 |
| TR4 | BC107/S | | | | 300553320 |
| IC1 | SC9496G | | | | 510090030 |
| IC2 | LM301A | | | | 510000620 |

## Component Parts List
## for
## Printed Circuit Board A2009003
## (Integrator and Reference)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R3 | MEFM | 820 | 1/8W | .5% | 192728202 |
| R4 | MEFM | 180k | 1/8W | .5% | 192751802 |
| R5 | MEFM | 150k | 1/8W | .5% | 192751502 |
| R6 | MEFM | 1.5k | 1/8W | .5% | 192731502 |
| R7 | MEFM | 1.5k | 1/8W | .5% | 192731502 |
| R8 | MEFM | 82k | 1/8W | .5% | 192748202 |
| R9 | CACP | 56 | 1/8W | 10% | 172015600 |
| R10 | MEFM | 12k | 1/8W | .5% | 192741202 |
| R11 | MEFM | 12k | 1/8W | .5% | 192741202 |
| R12 | MEFM | 10 | 1/8W | .5% | 192711002 |
| R18 | CACP | 47k | 1/8W | 10% | 172044700 |
| R20 | CACP | 47 | 1/8W | 10% | 172014700 |
| R21 | CACP | 56 | 1/8W | 10% | 172015600 |
| R22 | CACP | 2.2k | 1/8W | 10% | 172032200 |
| R23 | CACP | 15k | 1/8W | 10% | 172041500 |
| R24 | CACP | 15k | 1/8W | 10% | 172041500 |
| R25 | CACP | 10 | 1/8W | 10% | 172011000 |
| R26 | CACP | 470 | 1/8W | 10% | 172024700 |
| R27 | CACP | 1k | 1/4W | 10% | 172331000 |
| R28 | CACP | 1k | 1/8W | 10% | 172031000 |
| R29 | CACP | 15k | 1/8W | 10% | 172041500 |
| R30 | CACP | 1k | 1/8W | 10% | 172031000 |
| R32 | CACP | 220 | 1/4W | 10% | 172322200 |
| R34 | MEOX | 3.9k | 1/4W | 5% | 195633900 |
| R35 & R36 | Matched Set | | | | 169600301 |
| R37 | CACP | 22M | 1/4W | 10% | 172372200 |
| R38 to R41 & R47 | Matched Set | | | | 169600701 |
| R42 | MEFM | 75 | 1/8W | 1% | 192717501 |
| R43 | MEFM | 150 | 1/8W | .5% | 192721501 |
| R44 | MEFM | 300 | 1/8W | 1% | 192723001 |
| R45 | MEFM | 150 | 1/8W | .5% | 192721501 |
| R46 | MEFM | 300 | 1/8W | 1% | 192723001 |
| R48 | MEFM | 1.5k | 1/8W | .5% | 192731502 |
| R49 | MEFM | 1.5k | 1/8W | .5% | 192731502 |
| RV2 | WWPS | 5k | 1/4W | 5% | 130535000 |
| RV3 | WWPS | 5k | 1/4W | 5% | 130535000 |
| RV4 | WWPM | 20k | 1/8W | 10% | 121242000 |
| RV5 | CMPM | 100 | 1/8W | 10% | 110016040 |
| C5 to C9 | CERM | 33p | 500V | 20% | 241313300 |
| C10 | TAND | 15 | 20V | 20% | 265871500 |
| C11 to C13 | CERM | 0.1 | 30V | +50% −25% | 242051000 |
| C14 | STYR | 0.15 | 63V | 10% | 209951500 |
| C15 | ESTM | 2.2 | 100V | 10% | 225462200 |
| C16 | TAND | 15 | 20V | 20% | 265871500 |
| C17 | CERM | 1000p | 500V | 20% | 241331000 |
| D2 | IN829 | | | | 300525400 |

| Cct Ref. | General Description | Solartron Part No. |
|---|---|---|
| D3 to D7 | 1N3595 | 300523590 |
| D8 | SD3 | 300522160 |
| D9 | BZY88 C4V3 | 300523900 |
| D10 | BZY88 C4V3 | 300523900 |
| D11 | BZY88 C6V2 | 300521240 |
| D12 | BZY88 C12 | 300521480 |
| D13 | SD3 | 300522160 |
| D14 | SD3 | 300522160 |
| TR3 | U1899E | 300554320 |
| TR4 | U1897E | 300553800 |
| TR5 to TR9 | U1897E | 300553800 |
| TR10 | U235 | 300553810 |
| TR11 | 2N2369 | 300552390 |
| IC1 | A747C | 510090020 |
| IC2 | 741C | 510000591 |
| IC3 | 710C | 510000241 |
| Spreader Pad | | 300584340 |
| Ceramic Spacer | | 470120100 |

## Component Parts List
## for
## Printed Circuit Board A2009004
## (Logic and Toroid Drivers)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 to R5 | CACP | 1k | 1/4W | 10% | 172331000 |
| R7 | CACP | 4.7k | 1/4W | 10% | 172334700 |
| R9 | CACP | 15k | 1/4W | 10% | 172341500 |
| R10 | CACP | 4.7k | 1/4W | 10% | 172334700 |
| R11 | CACP | 15k | 1/4W | 10% | 172341500 |
| R12 | CACP | 4.7k | 1/4W | 10% | 172334700 |
| R14 | MEOX | 180 | 1W | 5% | 193421800 |
| R17 | CACP | 1k | 1/4W | 10% | 172331000 |
| R18 to R20 | CACP | 1k | 1/8W | 10% | 172031000 |
| R21 | CACP | 2.2k | 1/8W | 10% | 172032200 |
| R23 | CACP | 2.2k | 1/8W | 10% | 172032200 |
| R24 | CACP | 120 | 1/4W | 10% | 172321200 |
| C1 | TAND | 1 | 25V | +100% −20% | 266061000 |
| C2 | ALME | 200 | 10V | +50% −10% | 273182200 |
| C3 | TAND | 100 | 10V | 20% | 265481000 |
| D1 to D8 | SD3 | | | | 300522160 |
| D10 | 1N4733A | | | | 300524370 |
| D11 | SD3 | | | | 300522160 |
| TR1 to TR5 | 2N2369 | | | | 300552390 |
| TR7 | A1778 | | | | 300551430 |
| IC1 | SN15846N | | | | 510000160 |
| IC2 | SN7474N | | | | 510000490 |
| IC3 | SN15846N | | | | 510000160 |
| IC4 | SN15862N | | | | 510000200 |
| IC5 | SN15846N | | | | 510000160 |
| IC6 | SN15846N | | | | 510000160 |

## Component Parts List
## for
## Printed Circuit Board A2009005
## (Floating Power Supply and F.E.T. Drivers)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 | CACP | 22 | 1/8W | 10% | 172012200 |
| R2 | CACP | 22 | 1/8W | 10% | 172012200 |
| R3 | CACP | 12k | 1/8W | 10% | 172041200 |
| R4 | CACP | 2.2k | 1/8W | 10% | 172032200 |
| R5 to R7 | CACP | 1k | 1/8W | 10% | 172031000 |
| R8 | CACP | 10k | 1/8W | 10% | 172041000 |
| R9 | CACP | 12k | 1/8W | 10% | 172041200 |
| R10 | CACP | 2.2k | 1/8W | 10% | 172032200 |
| R11 | CACP | 1k | 1/8W | 10% | 172031000 |
| R12 | CACP | 1k | 1/8W | 10% | 172031000 |
| R13 | CACP | 10k | 1/8W | 10% | 172041000 |
| R14 | CACP | 12k | 1/8W | 10% | 172041200 |
| R15 | CACP | 2.2k | 1/8W | 10% | 172032200 |
| R16 | CACP | 1k | 1/8W | 10% | 172031000 |
| R17 | CACP | 1k | 1/8W | 10% | 172031000 |
| R18 | CACP | 10k | 1/8W | 10% | 172041000 |
| R19 | CACP | 2.2k | 1/8W | 10% | 172032200 |
| R20 | CACP | 47k | 1/8W | 10% | 172044700 |
| R21 | CACP | 10k | 1/8W | 10% | 172041000 |
| R22 | CACP | 1.5k | 1/8W | 10% | 172031500 |
| R23 | CACP | 1k | 1/8W | 10% | 172031000 |
| R24 | CACP | 680 | 1/8W | 10% | 172026800 |
| R25 | CACP | 33k | 1/8W | 10% | 172043300 |
| R26 | CACP | 33k | 1/8W | 10% | 172043300 |
| C1 to C4 | CERM | 33p | 500V | 20% | 241313300 |
| C6 | TAND | 47 | 35V | 20% | 266074700 |
| C7 | TAND | 15 | 20V | 20% | 265871500 |
| C8 | TAND | 15 | 20V | 20% | 265871500 |
| C9 | TAND | 47 | 35V | 20% | 266074700 |
| C10 | TAND | 100 | 20V | 20% | 265881000 |
| C12 | TAND | 100 | 20V | 20% | 265881000 |
| C13 | TAND | 100 | 20V | 20% | 265881000 |
| L1 to L3 | | 68 | | 10% | 305020370 |
| D1 | SD3 | | | | 300522160 |
| D2 | SD3 | | | | 300522160 |
| D4 | BAY 72 | | | | 300524530 |
| D5 | BAY 72 | | | | 300524530 |
| D6 to D11 | BAY 72 | | | | 300524530 |
| D12 | Zener | 2.7V | | | 300523870 |
| D13 | Zener | 2.7V | | | 300523870 |
| TR1 | 2N2369 | | | | 300552390 |
| TR2 | BCY70 | | | | 300553590 |
| TR3 | 2N2369 | | | | 300552390 |
| TR4 | BCY70 | | | | 300553590 |
| TR5 | 2N2369 | | | | 300552390 |
| TR6 | BCY70 | | | | 300553590 |
| TR7 | BCY70 | | | | 300553590 |
| TR8 | BC1075 | | | | 300553320 |
| TR9 | BC107 | | | | 300553320 |

## Component Parts List
## for
## Printed Circuit Board A2009006
## (Floating Mother Board, A200 and A203)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 to R4 R5 | 2.475M / 100k | Matched Set | | | 169602401 |
| R6 | MEOX | 3.3k | 1/4W | 5% | 195633300 |
| R7 | MEOX | 3.3k | 1/4W | 5% | 195633300 |
| R8 | MEOX | 220 | 1/16W | 1% | 192622202 |
| RV1 | WWPM | 200 | 0.75W | 10% | 122022000 |
| RV2 | WWPM | 20k | | | 121242000 |
| C1 | CERM | 470p | 500V | 20% | 241324700 |
| D1 | Zener | C3V3 | 3.3V | 5% | 300521860 |
| D2 | Zener | C4V7 | 4.7V | 5% | 300521470 |
| SKT A | | | | | 352516280 |
| SKT B | | | | | 352516280 |
| SKT D | | | | | 352516280 |
| SKT E | | | | | 352516280 |
| SKT F | | | | | 352524250 |
| SKT H | | | | | 352516280 |
| RLL | Relay VP4 (Silenced) | | | | 301200701 |
| Polarizing Key | | | | | 354003791 |
| Pivot Moulding | | | | | A2000090 |

## Component Parts List
## for
## Printed Circuit Board A2209006
## (Floating Mother Board, A220 and A223)

| Cct Ref. | General Description | | Solartron Part No. |
|---|---|---|---|
| R1 to R4 R5 | 2.475M / 99.95k | Matched Set | 169602401 |

All other components as per A200 and A203 Floating Mother Board Parts List.

## Component Parts List
## for
## Printed Circuit Board A2009007
## (Display)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 | CACP | 39k | ¼W | 10% | 172343900 |
| R2 to R6 | CACP | 22k | ¼W | 10% | 172342200 |
| R7 | CACP | 68k | ¼W | 10% | 172346800 |
| R8 to R10 | CACP | 4.7k | 1/8W | 10% | 172034700 |
| R11 | CACP | 220 | 1/8W | 10% | 172022200 |
| R12 to R16 | CACP | 4.7k | 1/8W | 10% | 172034700 |
| R17 | CACP | 1.8k | 1/8W | 10% | 172031800 |
| R18 | CACP | 56k | ¼W | 10% | 172345600 |
| R19 to R23 | CACP | 1.8k | 1/8W | 10% | 172031800 |
| R24 | CACP | 4.7k | 1/8W | 10% | 172034700 |
| R25 to R27 | CACP | 12k | 1/8W | 10% | 172041200 |
| R28 | CACP | 56k | ¼W | 10% | 172345600 |
| R29 | CACP | 56k | ¼W | 10% | 172345600 |
| D1 to D9 | SD3 | | | | 300522160 |
| D10 | Zener | 2.7V | | | 300523870 |
| D11 | SD3 | | | | 300522160 |
| TR1 to TR12 | A1778 | | | | 300551430 |
| TR13 | 40327 | | | | 300552890 |
| TR14 | 40327 | | | | 300552890 |
| TR15 | A1778 | | | | 300551430 |
| IC1 to IC4 | SN74141N | | | | 510000471 |
| ILP1 to ILP5 | Neon Indicator 16H/5 | | | | 300720300 |
| V1 | Numicator ZM1263 | | | | 300011411 |
| V2 to V6 | Numicator ZM1175 | | | | 300011400 |
| V7 | Neon Indicator 16H/5 | | | | 300720300 |

## Component Parts List
## for
## Printed Circuit Board A2009008
## (Control Discrete Circuit)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 | CACP | 1k | 1/8W | 10% | 172031000 |
| R2 | CACP | 2.2k | 1/8W | 10% | 172032200 |
| R3 | CACP | 1M | 1/8W | 10% | 172061000 |
| R4 | CACP | 1M | 1/8W | 10% | 172061000 |
| R5 | CACP | 100k | 1/8W | 10% | 172051000 |
| R6 | CACP | 1k | 1/8W | 10% | 172031000 |
| R7 | CACP | 10k | 1/8W | 10% | 172041000 |
| R8 | CACP | 470 | 1/8W | 10% | 172024700 |
| R9 | CACP | 1k | 1/8W | 10% | 172031000 |
| R10 | CACP | 33k | 1/8W | 10% | 172043300 |
| R11 | CACP | 3.3k | 1/8W | 10% | 172033300 |
| R12 | CACP | 100k | 1/8W | 10% | 172051000 |
| R13 | CACP | 4.7k | 1/8W | 10% | 172034700 |
| R14 | CACP | 1k | 1/8W | 10% | 172031000 |
| R15 | CACP | 1k | 1/8W | 10% | 172031000 |
| R16 | CACP | 4.7k | 1/4W | 10% | 172334700 |
| R17 | CACP | 4.7k | 1/4W | 10% | 172334700 |
| R18 | CACP | 18k | 1/8W | 10% | 172041800 |
| R19 | CACP | 1k | 1/8W | 10% | 172031000 |
| R20 | CACP | 4.7k | 1/8W | 10% | 172034700 |
| R21 | CACP | 4.7k | 1/8W | 10% | 172034700 |
| R22 | CACP | 2.2k | 1/8W | 10% | 172032200 |
| R23 | CACP | 1k | 1/8W | 10% | 172031000 |
| R24 | CACP | 3.3k | 1/4W | 10% | 172333300 |
| R25 | CACP | 3.3k | 1/4W | 10% | 172333300 |
| R31 | CACP | 1k | 1/8W | 10% | 172031000 |
| R33 | CACP | 1k | 1/8W | 10% | 172031000 |
| R35 | CACP | 100 | 1/8W | 10% | 172021000 |

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| C1 | ESTF | 1000p | 400V | 10% | 222331000 |
| C2 | ESTF | 1000p | 400V | 10% | 222331000 |
| C3 | ESTM | 1 | 100V | 10% | 225461000 |
| C4 | ESTM | 0.047 | 100V | 10% | 225444700 |
| C5 | ESTM | 0.1 | 100V | 10% | 225451000 |
| *C6 | STYR | 18p | 125V | 10% | 210211800 |
| C7 | CERM | 0.1 | 30V | +50% −25% | 242051000 |
| *C8 | STYR | 150p | 500V | 1% | 210321500 |
| C9 | CERM | 3300p | 500V | 20% | 241333300 |
| C10 | ESTM | 0.047 | 100V | 10% | 225444700 |
| C11 | CERM | 100p | 500V | 20% | 241321000 |
| C12 | CERM | 100p | 500V | 20% | 241321000 |
| C13 | TAND | 22 | 15V | 20% | 265672200 |
| C14 | TAND | 22 | 15V | 20% | 265672200 |
| C15 | CERM | 0.01 | 25V | +50% −25% | 241941000 |
| C16 | CERM | 0.01 | 25V | +50% −25% | 241941000 |
| C17 | TAND | 22 | 15V | 20% | 265672200 |
| D1 | SD3 | | | | 300522160 |
| D2 | SD3 | | | | 300522160 |
| D3 | Zener | 2.7V | | | 300523870 |
| D4 | IN3595 | | | | 300523590 |
| D5 | IN3595 | | | | 300523590 |
| D6 | Zener | 6.2V | | | 300521240 |
| D7 | SD3 | | | | 300522160 |
| D8 | SD3 | | | | 300522160 |
| D9 to D22 | SD3 | | | | 300522160 |
| D23 | 9.1V | | | | 300521340 |
| TR1 | BFX37 | | | | 300553030 |
| TR2 | 2N2484 | | | | 300552860 |
| TR3 | U1899E | | | | 300554320 |
| TR4 | SM6526 | | | | 300552990 |
| TR5 | BC107S | | | | 300553320 |
| TR6 | SM6526 | | | | 300552990 |
| TR7 | BC107S | | | | 300553320 |
| TR8 | BC107S | | | | 300553320 |
| TR9 | A1672 | | | | 300551910 |
| TR10 | A1672 | | | | 300551910 |
| TR11 | BC107S | | | | 300553320 |
| TR12 | BC107S | | | | 300553320 |
| TR13 | ZN2484 | | | | 300552860 |
| IC1 | SN15836N | | | | 510000290 |
| IC2 | SN15862N | | | | 510000200 |
| T1 | | | | | 309600101 |

* For 60Hz, values are as follows

| | | |
|---|---|---|
| C6 | 10p | 210211000 |
| C8 | 100p | 210321000 |

## Component Parts List
## for
## Printed Circuit Board A2209008
## (Control Discrete Circuits)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R13 | CACP | 4.7k | 1/8W | 10% | 172034700 |
| R14 | CACP | 1k | 1/8W | 10% | 172031000 |
| R15 | CACP | 1k | 1/8W | 10% | 172031000 |
| R16 | CACP | 4.7k | 1/4W | 10% | 172334700 |
| R17 | CACP | 4.7k | 1/4W | 10% | 172334700 |
| R18 | CACP | 18k | 1/8W | 10% | 172041800 |
| R19 | CACP | 1k | 1/8W | 10% | 172031000 |
| R20 | CACP | 4.7k | 1/8W | 10% | 172034700 |
| R21 | CACP | 4.7k | 1/8W | 10% | 172034700 |
| R22 | CACP | 2.2k | 1/8W | 10% | 172032200 |
| R23 | CACP | 1k | 1/8W | 10% | 172031000 |
| R24 | CACP | 3.3k | 1/4W | 10% | 172333300 |
| R25 | CACP | 3.3k | 1/4W | 10% | 172333300 |
| R31 | CACP | 1k | 1/8W | 10% | 172031000 |
| R33 | CACP | 1k | 1/8W | 10% | 172031000 |
| R34 | CACP | 1k | 1/4W | 10% | 172331000 |
| R35 | CACP | 100 | 1/8W | 10% | 172021000 |
| *C8 | STYR | 150p | 500V | 1% | 210321500 |
| C9 | CERM | 3300p | 500V | 20% | 241333300 |
| C10 | ESTM | 0.047 | 100V | 10% | 225444700 |
| C11 | CERM | 100p | 500V | 20% | 241321000 |
| C12 | CERM | 100p | 500V | 20% | 241321000 |
| C13 | TAND | 22 | 15V | 20% | 265672200 |
| C14 | TAND | 22 | 15V | 20% | 265672200 |
| C15 | CERM | 0.01 | 25V | +50% −20% | 241941000 |
| C17 | TAND | 22 | 15V | 20% | 265672200 |
| D7 to D22 | SD3 | | | | 300522160 |
| D23 | Zener | 9.1V | | | 300521340 |
| TR6 | SM6526 | | | | 300552990 |
| TR7 | BC107S | | | | 300553320 |
| TR8 | BC107S | | | | 300553320 |
| TR9 | 2N2369 | | | | 300552390 |
| TR10 | 2N2369 | | | | 300552390 |
| TR11 | BC107S | | | | 300553320 |
| TR12 | BC107S | | | | 300553320 |
| TR13 | ZN2484 | | | | 300552860 |
| IC1 | SN15836N | | | | 510000290 |
| IC2 | SN15862N | | | | 510000200 |
| T1 | Oscillator Coil | | | | 309600101 |

* For 60Hz, value is changed as follows:-

| | | |
|---|---|---|
| C8 | 100p | 210321000 |

## Component Parts List
## for
## Printed Circuit Board A2009009
## (Control Logic)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 | CACP | 1k | ¼W | 10% | 172331000 |
| R2 | CACP | 1k | ¼W | 10% | 172331000 |
| D1 | SD3 | | | | 300522160 |
| IC1 to IC3 | SN15846N | | | | 510000160 |
| IC4 | SN15830N | | | | 510000100 |
| IC5 | SN15846N | | | | 510000160 |
| IC6 | SN7490N | | | | 510000280 |
| IC7 to IC11 | SN15846N | | | | 510000160 |
| IC12 | SN158093N | | | | 510000300 |
| IC13 | SN158093N | | | | 510000300 |
| IC14 | SN7474 | | | | 510000490 |
| IC15 | SN15836N | | | | 510000290 |
| IC16 | SN15862N | | | | 510000200 |

## Component Parts List
## for
## Printed Circuit Board A2009010
## (Range and Mode Logic)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 | CACP | 33k | 1/8W | 10% | 172043300 |
| C1 | TAND | 47μ | 6V | 20% | 265274700 |
| IC1 | SN15862N | | | | 510000200 |
| IC2 | SN15836N | | | | 510000290 |
| IC3 | SN15862N | | | | 510000200 |
| IC4 | SN15846N | | | | 510000160 |
| IC5 | SN15846N | | | | 510000160 |
| IC6 | SN15846N | | | | 510000160 |
| IC7 | SN15862N | | | | 510000200 |
| IC8 | SN15846N | | | | 510000160 |
| IC9 | SN15846N | | | | 510000160 |
| IC10 | SN158093N | | | | 510000300 |
| IC11 | SN158093N | | | | 510000300 |
| IC12 | SN74121N | | | | 510000530 |
| IC13 | SN15846N | | | | 510000160 |
| IC14 | SN7407N | | | | 510000750 |
| IC15 | SN15846N | | | | 510000160 |
| IC16 | SN15862N | | | | 510000200 |

## Component Parts List
## for
## Printed Circuit Board A2209010
## (Range and Mode Logic)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 | CACP | 33k | 1/8W | 10% | 172043300 |
| C1 | TAND | 47 | 6V | 20% | 265274700 |
| IC1 | SN15846N | | | | 510000160 |
| IC2 | SN15846N | | | | 510000160 |
| IC3 | SN15836N | | | | 510000290 |
| IC4 | SN15862N | | | | 510000200 |
| IC5 | SN15862N | | | | 510000200 |
| IC6 | SN15846N | | | | 510000160 |
| IC7 | SN7407N | | | | 510000750 |
| IC8 | SN158093N | | | | 510000300 |
| IC9 | SN15846N | | | | 510000160 |
| IC10 | SN74121N | | | | 510000530 |

## Component Parts List
## for
## Printed Circuit Board A2009011
## (Counter Logic)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 | CACP | 2.2k | 1/8W | 10% | 172032200 |
| R2 | CACP | 2.2k | 1/8W | 10% | 172032200 |
| D1 to D5 | SD3 | | | | 300522160 |
| IC1 | SN7406N | | | | 510000760 |
| IC2 | SN15830N | | | | 510000100 |
| IC3 | SN158093N | | | | 510000300 |
| IC4 | SN7475N | | | | 510000350 |
| IC5 | SN7490N | | | | 510000280 |
| IC6 | SN7475N | | | | 510000350 |
| IC7 | SN7490N | | | | 510000280 |
| IC8 | SN7475N | | | | 510000350 |
| IC9 | SN7490N | | | | 510000280 |
| IC10 | SN7475N | | | | 510000350 |
| IC11 | SN7490N | | | | 510000280 |
| IC12 | SN7475N | | | | 510000350 |
| IC13 | SN15862N | | | | 510000200 |
| IC14 | SN7475N | | | | 510000350 |
| IC15 | SN15862N | | | | 510000200 |
| IC16 | SN15846N | | | | 510000160 |
| IC17 | SN15846N | | | | 510000160 |
| IC18 | SN15846N | | | | 510000160 |

## Component Parts List
## for
## Printed Circuit Board A2009012
## (Power Supply Inverter Board)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R2 | MEOX | 150 | 1W | 5% | 193421500 |
| R3 | MEOX | 47 | 1W | 5% | 193414700 |
| R11 | CACP | 1.5k | 1/4W | 10% | 172331500 |
| R15 | CACP | 10 | 1/8W | 10% | 172011000 |
| R16 | CACP | 220k | 1/8W | 10% | 172052200 |
| R17 | MEOX | 150 | 1W | 5% | 193421500 |
| R18 | CACP | 220k | 1/8W | 10% | 172052200 |
| R19 | CACP | 10 | 1/8W | 10% | 172011000 |
| R20 | CACP | 2.2 | 1/4W | 10% | 172302200 |
| R21 | CACP | 2.2 | 1/4W | 10% | 172302200 |
| R22 | CACP | 680 | 1/4W | 10% | 172326800 |
| R23 | CACP | 2.2k | 1/4W | 10% | 172332200 |
| C4 | | 6800p | 500V | | 241036800 |
| C5 | TAND | 47 | 35V | 20% | 266074700 |
| C6 | ALME | 5 | 150V | +50% −10% | 271665000 |
| C7 | ALME | 5 | 150V | +50% −10% | 271665000 |
| C8 | TAND | 15 | 20V | 20% | 265871500 |
| C9 | TAND | 15 | 20V | 20% | 265871500 |
| C10 | | 200 | 10V | +50% −10% | 273182200 |
| C13 | CERM | 470 | 500V | 20% | 241324700 |
| C14 | CERM | 0.01 | 25V | +50% −20% | 241941000 |
| C15 | CERM | 0.01 | 25V | +50% −20% | 241941000 |
| C16 | CERM | 0.047 | 25V | +50% −20% | 241944700 |
| C17 | TAND | 15 | 20V | 20% | 265871500 |
| L3 | | 68 | | 10% | 305020370 |
| L4 | | 68 | | 10% | 305020370 |
| L5 | | 300 | | | 309500101 |
| L6 | FX1115 | | | | 309010060 |
| L7 | FX1115 | | | | 309010060 |
| D2 to D5 | BA148 | | | | 300525070 |
| D6 | 1N4933 | | | | 300524830 |
| D7 | 1N4933 | | | | 300524830 |
| D8 to D13 | BAY 72 | | | | 300524530 |
| D19 | BAY 72 | | | | 300524530 |
| D20 | BAY 72 | | | | 300524530 |

| Cct Ref. | General Description | Solartron Part No. |
|---|---|---|
| T1 | Timing | 309600501 |
| T2 | Inverter | 309600303 |
| | Board for T2 | A2009024 |
| TR6 | BDX35 | 300555230 |
| TR7 | BDX35 | 300555230 |
| TR8 | 2N2218A | 300552000 |
| TR9 | 2N2053 | 300551800 |

## Component Parts List
## for
## Printed Circuit Board A2009013
## (Earthy Mother Board)

| Cct Ref. | General Description | Solartron Part No. |
|---|---|---|
| SKT1 to SK3 | Connector 24-24 PWC | 352524250 |
| SKT4 | Connector 16-16 PWC | 352516280 |
| SKT5 | Connector 32-32 PWC | 352532290 |
| SKT6 | Connector 44-WAY | 352544060 |
| | Polarizing Key | 354003791 |

## Component Parts List
## for
## Printed Circuit Board A2009014
## (A.C. Converter, A203 and A223)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 | CACP | 10M | 1/2W | 5% | 170871000 |
| R2 | POWW | 15k | 3W | 5% | 173741500 |
| R3 | MEOX | 3.9k | 1/4W | 5% | 195633900 |
| R4 | MEOX | 1k | 1/4W | 5% | 195631000 |
| R5 | CACP | 3.9k | 1/8W | 10% | 172033900 |
| R6 | MEOX | 3.9k | 1/4W | 5% | 195633900 |
| R7 | MEOX | 1k | 1/4W | 5% | 195631000 |
| R8 | CACP | 3.9k | 1/8W | 10% | 172033900 |
| R9 | CACP | 1.5k | 1/8W | 10% | 172031500 |
| R10 | CACP | 3.3k | 1/8W | 10% | 172033300 |
| R11 | CACP | 330 | 1/8W | 10% | 172023300 |
| R12 | CACP | 270 | 1/8W | 10% | 172022700 |
| R13 | CACP | 10M | 1/4W | 10% | 172371000 |
| R14 | CACP | 1k | 1/2W | 10% | 172031000 |
| R15 | CACP | 10k | 1/8W | 10% | 172041000 |
| R16 | CACP | 3.9k | 1/8W | 10% | 172033900 |
| R17 | CACP | 39 | 1/8W | 10% | 172013900 |
| R18 | CACP | 390 | 1/8W | 10% | 172023900 |
| R19 | MEOX | 3.9k | 1/2W | 5% | 193533900 |
| R20 | MEOX | 180 | 1/4W | 5% | 195621800 |
| R21 | MEOX | 330 | 1/4W | 5% | 195623300 |
| R22 to R25 | | | Set of 4 | | 169601201 |
| R26 | MEFM | 1.5 | 1/8W | 1% | 191201502 |
| R27 | MEFM | 15k | 1/8W | 0.5% | 192741502 |
| R28 | CACP | 10 | 1/8W | 10% | 172011000 |
| R29 and R31 | | 47.67k | Set of 2 | | 169601001 |
| R30 | MEFM | 12.5k | 1/4W | 1% | 198141251 |
| R32 | CACP | 10 | 1/8W | 10% | 172011000 |
| R33 | POWW | 15k | 3W | 5% | 173741500 |
| R34 | CACP | 1.5k | 1/8W | 10% | 172031500 |
| R36 | MEOX | 120k | 1/4W | 5% | 195651200 |
| R37 | MEOX | 1k | 1/4W | 5% | 195631000 |
| R38 | MEOX | 1k | 1/4W | 5% | 195631000 |
| R39 | MEOX | 120k | 1/4W | 5% | 195651200 |

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| RV1 | CMPM | 100 | 1/8W | 10% | 110016040 |
| RV2 | CMPM | 2000 | 1/4W | 10% | 124032000 |
| RV3 | CAPS | 2200 | 1/2W | 20% | 137332200 |
| C1 | | 0.033 | 630V | 20% | 226443300 |
| C2 | ESTF | 4700p | 160V | 10% | 221334700 |
| C3 | CERM | 0.047 | 25V | +50% −25% | 241944700 |
| C4 | ESTF | 4700p | 160V | 10% | 221334700 |
| C5 | ESTF | 3300p | 160V | 10% | 221333300 |
| C6 | TAND | 2.2 | 20V | 20% | 265862200 |
| C7 | CERM | 82p | 500V | 20% | 241518200 |
| C8 | CERM | 15p | 500V | 20% | 241311500 |
| C9 | CERM | 0.1 | 30V | +50% −25% | 242051000 |
| C10 | ESTM | 0.68 | 100V | 10% | 225456800 |
| C11 | ESTM | 0.1 | 100V | 10% | 225451000 |
| C12 | CERM | 0.1 | 30V | +50% −25% | 242051000 |
| C13 | ESTM | 1.0 | 100V | 10% | 225461000 |
| C14 | ESTM | 1.0 | 100V | 10% | 225461000 |
| C15 | CERM | 33p | 500V | 20% | 241313300 |
| C16 | CERM | 330p | 500V | 20% | 241323300 |
| C17 | CERM | 4.7p | 500V | 20% | 241304700 |
| C18 | CERM | 4.7p | 500V | 20% | 241304700 |
| L1 | FX1115 | | | | 309010060 |
| D1 | Zener | 7.5V | | | 300521460 |
| D2 | IN3595 | | | | 300523590 |
| D3 | Zener | 5.6V | | | 300521450 |
| D4 | IN3595 | | | | 300523590 |
| D5 | Zener | 5.6V | | | 300521450 |
| D6 | Zener | 7.5V | | | 300521460 |
| D7 | SD3 | | | | 300522160 |
| D8 | SD3 | | | | 300522160 |
| D9 | Zener | 6.2V | | | 300521240 |
| D10 | SD3 | | | | 300522160 |
| D11 | SD3 | | | | 300522160 |
| D12 | Zener | 3.9V | | | 300521420 |
| D13 | Zener | 3.9V | | | 300521420 |
| D14 | 5082—2800 Hewlett Packard | | | | 300524910 |
| D15 | 5082—2800 Hewlett Packard | | | | 300524910 |
| D16 | SD3 | | | | 300522160 |
| TR1 | | | | | 300553810 |
| TR2 | BC107S | | | | 300553320 |
| TR3 | BC107B | | | | 300554420 |
| TR4 | BC107S | | | | 300553320 |
| TR5 | SM6526 | | | | 300552990 |
| TR6 | BC107S | | | | 300553320 |
| IC1 | 709C | | | | 510000250 |
| RLT | 2 Pole: P.C.B. Type: (Silenced) | | | | 301200401 |
| Ceramic Spacers | | | | | 470120100 |
| Aluminium Screen | | | | | A2000205 |
| Tubular Spacers | | | | | |

## Component Parts List
## for
## Printed Circuit Board A2009015
## (A.C. Auxiliary, A203 and A223)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 | MEFM | 990k | 2W | 0.1% | 169600501 |
| R2 | MEFM | 11k | 1/4W | 0.1% | 198141104 |
| R3 | MEFM | 100k | 1/4W | 1% | 198351002 |
| R4 | MEFM | 9.1k | 1/4W | 1% | 198339102 |
| R5 | MEFM | 1.1k | 1/4W | 0.1% | 198131104 |
| R6 | MEOX | | 1W | 5% | 193422200 |
| R7 | PRWW | 10.95k | 1/4W | 0.1% | 169600901 |
| R8 | MEFM | 33k | 1/4W | 1% | 198343302 |
| R9 | CACP | 150 | 1/4W | 10% | 172321500 |
| R10 | CACP | 150 | 1/4W | 10% | 172321500 |
| RV1 | CMPM | 20k | 1/2W | 10% | 124042000 |
| RV2 | CMPM | 2k | 1/2W | 10% | 124032000 |
| RV3 | | 100 | 1/8W | 10% | 110016040 |
| C1 | MICA | 680p | 350V | 5% | 250326800 |
| C3 | MICA | 6800 p | 350V | 5% | 250336800 |
| C4 | CERM | 0.1 | 30V | +50% −25% | 242051000 |
| C5 | CERM | 0.1 | 30V | +50% −25% | 242051000 |
| C6 | OXLEY | 0.5-5p | 2kV | | 290060060 |
| C7 | OXLEY | 0.5-5p | 2kV | | 290060060 |
| C8 | TAND | 100 | 20V | 20% | 265881000 |
| C9 | TAND | 100 | 20V | 20% | 265881000 |
| D1 to D4 | SD3 | | | | 300522160 |
| D5 | Zener | 5.1V | | | 300521310 |
| IC1 | SM7407 | | | | 510000/50 |
| IC2 | 946 | | | | 510000160 |
| IC3 | SN7406N | | | | 510000760 |
| RLR | 4 Pole | | | | 301201401 |
| RLS | 2 Pole | | | | 301200203 |
| RLU | 2 Pole | | | | 301200605 |
| RLV | 2 Pole | | | | 301200605 |

## Component Parts List
## for
## Printed Circuit Board A2009016
## (Ohms and A.C. Filter, A203 and A223)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 and R4 | | 50k | Matched Set | | 169600602 |
| R2 | MEFM | 36k | 1/4W | 1% | 198343602 |
| R3 | MEFM | 36k | 1/4W | 1% | 198343602 |
| R5 | MEFM | 2.2M | 1/4W | 1% | 198362202 |
| R6 | MEFM | 680k | 1/8W | 0.5% | 192756802 |
| R7 | MEOX | 8.2k | 1/4k | 1% | 195638200 |
| R8 | PRWW | 10k | 1/4W | 0.05% | 169600801 |
| R10 | MEFM | 22k | 1/8W | 0.5% | 192742202 |
| R11 | MEFM | 22k | 1/4W | 1% | 198342202 |
| R12 | MEOX | 47k | 1/4W | 5% | 195644700 |
| R13 | MEOX | 820 | 1/4W | 5% | 195628200 |
| R14 | MEFM | 22k | 1/2W | 1% | 198642202 |
| R15 | MEFM | 18k | 1/8W | 0.5% | 192741802 |
| R16 | CACP | 100 | 1/8W | 10% | 172021000 |
| R17 | CACP | 1k | 1/8W | 10% | 172031000 |
| R18 | MEOX | 220 | 1/4W | 5% | 195622200 |
| R19 | MEOX | 220 | 1/4W | 5% | 195622200 |
| R20 | MEOX | 8.2k | 1/4k | 5% | 195638200 |
| R21 | MEFM | 1k | 1/8W | 0.5% | 192731002 |
| RV1 | WWPM | 1k | 1/2W | 10% | 121231000 |
| RV2 | WWPM | 1k | 1/2W | 10% | 121231000 |

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| C1 | CARB | 2.2 | 100V | 10% | 208900002 |
| C2 | CARB | 2.2 | 100V | 10% | 208900002 |
| C3 | ESTM | 6.8 | 100V | 10% | 225466800 |
| C4 | ESTM | 6.8 | 100V | 10% | 225466800 |
| C5 | ESTM | 1.5 | 100V | 10% | 225461500 |
| C6 | ESTM | 1.5 | 100V | 10% | 225461500 |
| C7 | ESTM | 3.3 | 100V | 10% | 225463300 |
| C8 | ESTM | 3.3 | 100V | 10% | 225463300 |
| C9 | CERM | 0.1 | 30V | +50% −25% | 242051000 |
| C10 | CERM | 0.1 | 30V | +50% −25% | 242051000 |
| C11 | CERM | 220p | 500V | 20% | 241322200 |
| C12 | STYR | 33p | 125V | 10% | 210213300 |
| D1 to D3 | SD3 | | | | 300522160 |
| D4 | 1N3595 | | | | 300523590 |
| D5 | 1N3595 | | | | 300523590 |
| D7 | SD3 | | | | 300522160 |
| D8 | 1N4004 | | | | 300522070 |
| D9 | 1N3595 | | | | 300523590 |
| D10 | 1N3595 | | | | 300523590 |
| D11 to D13 | SD3 | | | | 300522160 |
| D14 | BAY72 | | | | 300524530 |
| D16 | 1N3595 | | | | 300523590 |
| TR1 | RCA40327 | | | | 300552890 |
| Spreader Pads | | | | | 300584340 |
| IC1 | SL13348 | | | | 510090080 |
| IC2 | 741C | | | | 510000591 |
| RLM | 4 Pole | | | | 300651860 |
| RLN | 4 Pole | | | | 301201102 |
| RLP | 4 Pole | | | | 301201102 |

## Component Parts List
## for
## Printed Circuit Board A2009022
## (Power Supply, Stabiliser Board)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 | POWW | 0.22 | 2.6W | 10% | 173500220 |
| R4 | CACP | 22k | 1/4W | 10% | 172342200 |
| R5 | CACP | 1k | 1/4W | 10% | 172331000 |
| R6 | CACP | 10k | 1/4W | 10% | 172341000 |
| R7 | CACP | 2.2k | 1/4W | 10% | 172332200 |
| R8 | CACP | 2.2k | 1/4W | 10% | 172332200 |
| R9 | CACP | 470 | 1/4W | 10% | 172324700 |
| R12 | MEFM | 4.7k | 1/8W | 0.5% | 192734702 |
| R13 | MEFM | 2.2k | 1/8W | 0.5% | 192732202 |
| R14 | CACP | 2.2k | 1/8W | 10% | 172032200 |
| RV1 | WWPM | 1k | 1/2W | 10% | 121231000 |
| C1 | CERM | 0.1 | 30V | +50% −25% | 242051000 |
| C2 | CERM | 0.1 | 30V | +50% −25% | 242051000 |
| C3 | CERM | 470 | 500V | 20% | 241324700 |
| C11 | ALME | 4700 | 40V | | 273894700 |
| C12 | TAND | 2.2 | 20V | 20% | 265862200 |

| Cct Ref. | General Description | Solartron Part No. |
|---|---|---|
| D1 | Zener 6.8V | 300522540 |
| D14 | SD3 | 300522160 |
| D15 to D18 | 1S020 | 300520670 |
| TR1 | BC107S | 300553320 |
| TR2 | BC107S | 300553320 |
| TR3 | SM6526 | 300552990 |
| TR4 | SM6526 | 300552990 |
| TR5 | BFY50 | 300553610 |
| Ceramic Spacer | (R1) | 470120100 |
| Ceramic Spacer | (D15 to D18) | 470111080 |

## Component Parts List
## for
## Printed Circuit Board A2009023
## (Range and Mode Switches)

| Cct Ref. | General Description | Solartron Part No. |
|---|---|---|
| SWA | 7-Way Switch Assembly | 379600301 |
| SWB | 3-Way Switch Assembly | 379600201 |

## Component Parts List
## for
## Printed Circuit Board A2009025
## (Local-Remote; Sample Rate: Filter Switches)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 | CACP | 1k | 1/8W | ±10% | 172031000 |
| C1 | CERM | .01 | 25V | +50% -25% | 241941000 |
| SWC | 2-Way Switch Assembly | | | | 379600101 |
| SWD | 2-Way Switch Assembly | | | | 379600401 |
| SWE | 2-Way Switch Assembly | | | | 379600101 |

## Component Parts List
## for
## Printed Circuit Board A2009026
## (Reed Relay: Input Filter: Feedback)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 | MEFM | 10k | 1/2W | 1% | 198641002 |
| R2 | MEFM | 10k | 1/2W | 1% | 198641002 |
| R3 | MEFM | 10k | 1/2W | 1% | 198641002 |
| R4 | CACP | 220 | 1/8W | 10% | 172022200 |
| R5 to R10 | PRWW | Matched Set | | | 169600401 |
| R11 | CACP | 220 | 1/8W | 10% | 172022200 |
| R12 | CACP | 220 | 1/8W | 10% | 172022200 |
| RV1 to RV4 | | 100 | 3/4W | 10% | 110016040 |
| LP1 | HIVAC A243 | | | | 300720430 |
| C1 | STYR | 2200p | 350V | 2½% | 208100124 |
| C2 | CARB | 0.68 | 100V | 10% | 208900001 |
| C3 | CARB | 2.2 | 100V | 10% | 208900002 |
| C4 | CARB | 0.022 | 400V | 10% | 208900003 |
| C5 | STYR | 100p | 125V | 5% | 208100070 |
| C6 | CERM | 0.7-3.3p | | | 290030040 |
| RLA1 | | | | | 379602601 |
| RLA2 | | | | | 379602601 |
| RLB1 | | | | | 379602601 |
| RLB2 | | | | | 379602601 |
| RLD1 | | | | | 379602601 |
| RLD2 | | | | | 379602601 |
| RLE1 | | | | | 379602601 |
| RLE2 | | | | | 379602601 |
| RLF1 | | | | | 379602601 |
| RLF2 | | | | | 379602601 |
| RLH1 | | | | | 379602601 |
| RLH2 | | | | | 379602601 |
| RLJ1 | | | | | 379602601 |
| RLJ2 | | | | | 379602601 |
| RLK1 | | | | | 379602601 |
| RLK2 | | | | | 379602601 |

## Component Parts List
## for
## Fan Out Main Assembly

| Cct Ref. | General Description | Solartron Part No. |
|---|---|---|
| SKT1 | 50-Way Conn. Shell Fixed | 354002330 |

## Component Parts List
## for
## Printed Circuit Board A2049027
## (Fan Out, Main Board)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 to R18 | CACP | 5.6kΩ | 1/8W | 10% | 172035600 |
| IC1 | SN7475N | | | | 510000350 |
| IC2 | SN7483N | | | | 510000841 |
| IC3 | SN15862N | | | | 510000200 |
| IC4 | SN15836N | | | | 510000290 |
| IC5 | SN15846N | | | | 510000160 |
| IC6 | SN15846N | | | | 510000160 |
| IC7 | SN15862N | | | | 510000200 |
| IC8 to IC10 | SN7407N | | | | 510000750 |

## Component Parts List
## for
## Printed Circuit Board A2049028
## (Fan Out, Sub Board)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 | CACP | 82k | 1/8W | 10% | 172048200 |
| R2 | CACP | 1k | 1/8W | 10% | 172031000 |
| R3 | MEFM | 33k | 1/8W | 1% | 192743302 |
| R4 | CACP | 4.7k | 1/8W | 10% | 172034700 |
| R5 | CACP | 10k | 1/8W | 10% | 172041000 |
| R6 | CACP | 3.3k | 1/8W | 10% | 172033300 |
| R7 | CACP | 1.8k | 1/8W | 10% | 172031800 |
| R8 | CACP | 5.6k | 1/8W | 10% | 172035600 |
| R9 | CACP | 10k | 1/8W | 10% | 172041000 |
| R10 | MEOX | 390k | 1/8W | 10% | 195453900 |
| R11 | CACP | 5.6k | 1/8W | 10% | 172035600 |
| R12 | CACP | 100 | 1/8W | 10% | 172021000 |
| R13 | | 1k | 1/8W | 10% | 172031000 |
| R14 | | 1k | 1/8W | 10% | 172031000 |
| R15 | | 470 | 1/8W | 10% | 172024700 |
| C1 | ESTM | 0.068 | 100V | 10% | 225446800 |
| C2 | CERM | 2200p | 500V | 25% | 208450065 |
| C3 | ESTM | 0.47 | 160V | 2% | 220154700 |
| C4 | TAND | 2.2 | 20V | 20% | 265862200 |
| C5 | CERM | 0.01 | 25V | 20% | 241941000 |

| Cct Ref. | General Description | Solartron Part No. |
|---|---|---|
| D1 to D4 | Diode SD3 | 300522160 |
| TR1 | SM6526 | 300552990 |
| TR2 | BC107/S | 300553320 |
| TR3 | BC107/S | 300553320 |
| IC1 | SN74121N | 510000530 |
| IC2 | SN7470N | 510000750 |
| IC3 | SN15836N | 510000290 |
| IC4 | SN7400N | 510000340 |
| IC5 | SN158093N | 510000300 |
| IC6 | SN7474N | 510000490 |
| IC7 | SN7474N | 510000490 |
| IC8 | SN7413N | 510000710 |

## Component Parts List
## for
## Printed Circuit Board A2009031
## (Link Board, A200 and A220)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 | MEFM | 1k | 1/8W | 1% | 192731002 |

## Component Parts List
## for
## Printed Circuit Board A2009034
## (Floating Power Supply Transformer)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| C5 | GLAS | 2-12pF | 2.5kV | | 290060030 |
| C14 | STYR | 6.8pF | 500V | ½pF | 208100087 |
| C15 | STYR | 6.8pF | 500V | ½pF | 208100087 |
| C17 | GLAS | 2-12p | 2.5kV | | 290060030 |
| T1 | Transformer Inv. | | | | 309600401 |

## Component Parts List
## for
## Printed Circuit Board A2009036
## (Toroid Driver & Receiver)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 to R5 | CACP | 1k | 1/8W | 10% | 172031000 |
| C1 | CERM | 0.047 | 25V | +50% -25% | 241944700 |
| C2 to C4 | CERM | 3300 | 500V | 20% | 241333300 |
| D1 to D8 | Diode SD3 | | | | 300522160 |

## Component Parts List
## for
## Printed Circuit Board A2009041
## (R.M.S. Converter)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 | CKCA | 10M | 1/2W | 5% | 170871000 |
| R2 | CACP | 100k | 1/8W | 10% | 172051000 |
| R3 | MEFM | 10k | 1/8W | 1% | 191241002 |
| R4 | CACP | 10k | 1/8W | 10% | 172041000 |
| R5 | MEFM | 10k | 1/8W | 1% | 191241002 |
| R7 | Attenuator | 1.179k | 1/10W | 0.1% | 169607101 |
| R8 | Attenuator | 131 | 1/10W | 0.1% | 169607101 |
| R9 | MEFM | 4.7 | 1/8W | 1% | 191204702 |
| R11 | MEOX | 33 | 1W | 5% | 193413300 |
| R12 | MEOX | 33 | 1W | 5% | 193413300 |
| R13 | Attenuator | 50k | 1/10W | 0.1% | 169607101 |
| R16 | CACP | 10M | 1/2W | 10% | 172371000 |
| R17 | CACP | 47k | 1/8W | 10% | 172044700 |
| R18 | MEFM | 10 | 1/8W | 1% | 191211003 |
| R19 | CACP | 10k | 1/8W | 10% | 172041000 |
| C1 | ESTM | 0.033 | 630V | 10% | 226343300 |
| C2 | ESTF | 0.01 | 400V | 10% | 222341000 |
| C4 | CERM | 3300p | 500V | +50% -25% | 241333300 |
| C5 | CERM | 3300p | 500V | +50% -25% | 241333300 |
| C6 | CERM | 22p | 500V | +50% -25% | 241312200 |
| C8 | TAND | 220 | 10V | 20% | 265482200 |
| C9 | ESTM | 0.47 | 100V | 10% | 225454700 |
| C10 | ESTM | 0.47 | 100V | 10% | 225454700 |
| C12 | ESTM | 2.2 | 63V | 10% | 225162200 |
| C14 | TAND | 1 | 100V | 10% | 225461000 |
| C15 | CERM | 100p | 500V | +50% -25% | 241321000 |
| D3 | BZY88 | 3.3V | 0.4W | 5% | 300521860 |
| D4 | BZY88 | 5.6V | 0.4W | 5% | 300521450 |
| D5 | IN4739A | 9.1V | | | 300525410 |
| D6 | IN4739A | 9.1V | | | 300525410 |
| D7 | BZY 88 | 5.6V | 0.4W | ±5 | 300521450 |
| D8 | SD3 | | | | 300522160 |
| D9 to D12 | IN3595 | | | | 300523590 |
| IC1 | LM318H | | | | 510090210 |
| IC2 | RMS Module Intronics R310 | | | | 550000840 |
| RLT | Relay Reed | | | | 300651030 |
| RV1 | CMPM | 500 | 3/4W | ±20 | 130625000 |
| RV2 | CMPM | 500 | 3/4W | ±20 | 130625000 |
| RV5 | CMPM | 20k | 3/4W | ±20 | 130642000 |
| TR1 | U235 | | | | 300553810 |
| TR2 | BC107 | | | | 300553320 |
| TR3 | BC107 | | | | 300553320 |

## Component Parts List
## for
## Printed Circuit Board A2009046
## (Display)

| Cct. Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 to R4 | MEOX | 68k | 1/2W | 5% | 193546800 |
| R5 | CACP | 1M | 1/8W | 10% | 172061000 |

| Cct. Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R6 | CACP | 1M | 1/8W | 10% | 172061000 |
| R7 | CACP | 2.2k | 1/8W | 10% | 172032200 |
| R8 | MEOX | 47k | 1/2W | 5% | 193544700 |
| R9 | MEOX | 68k | 1/2W | 5% | 193546800 |
| R10 | MEOX | 150k | 1/2W | 5% | 193551500 |
| R11 | MEOX | 100k | 1/2W | 5% | 193551000 |
| R12 | MEOX | 120k | 1/2W | 5% | 193551200 |
| R13 | CACP | 2.2k | 1/8W | 10% | 172032200 |
| R14 | MEOX | 120k | 1/2W | 5% | 193551200 |
| R15 | MEOX | 120k | 1/2W | 5% | 193551200 |
| R16 | MEOX | 100k | 1/2W | 5% | 193551000 |
| R17 | MEOX | 120k | 1/2W | 5% | 193551200 |
| D1 | Zener | 39V | 1W | | 300525480 |
| X1 | SP354 | | | | 300730290 |
| X2 | SP353 | | | | 300730280 |
| LP1 to LP7 | NS509/1 | | | | 300720450 |
| SK1 | Edge Connector | | | | 352544090 |

## Component Parts List

## for

## Printed Circuit Board A2009047

## (Display Driver)

| Cct Ref. | General Description | | | | Solartron Part No. |
|---|---|---|---|---|---|
| R1 | MEOX | 68k | 1/2W | 5% | 193546800 |
| R2 | CACP | 220 | 1/8W | 10% | 172022200 |
| R3 | CACP | 3.3k | 1/8W | 10% | 172033300 |
| R4 | CACP | 4.7k | 1/8W | 10% | 172034700 |
| R5 | CACP | 4.7k | 1/8W | 10% | 172034700 |
| R6 | CACP | 3.3k | 1/8W | 10% | 172033300 |
| R7 | CACP | 4.7k | 1/8W | 10% | 172034700 |
| R8 | CACP | 4.7k | 1/8W | 10% | 172034700 |
| R9 to R12 | MEOX | 12k | 1/4W | 5% | 195641200 |
| R13 to R16 | CACP | 3.3k | 1/8W | 10% | 172033300 |
| R17 to R20 | CACP | 470k | 1/8W | 10% | 172054700 |
| R21 to R24 | CACP | 4.7k | 1/8W | 10% | 172034700 |
| D1 | Zener | 2.7V | | | 300523870 |
| D2 to D10 | IS 921 | | | | 300522620 |
| TR1 to TR4 | 40327 | | | | 300552890 |
| TR5 to TR7 | A1778 | | | | 300551430 |
| TR8 to TR10 | 40327 | | | | 300552890 |
| TR11 to TR14 | A1778 | | | | 300551430 |
| IC1 to IC4 | Decoder/Driver Sperry | | | | 510001600 |
| V1 | Neon Lamp 16H | | | | 300720220 |

www.manualsplus.com
1003404